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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

SOME CHEMICAL RELATIONS OF PLANT AND SOIL[1]

IN order to arrive at a satisfactory theory of living matter it is evidently necessary to know what substances are indispensable to metabolism and to ascertain the rôle of each of these substances.

Despite much study it is not yet clear what constituents of the soil are absolutely needful for plants. An excellent example is found in sodium chloride, which is indispensable for animals, but is generally thought to be unnecessary for plants. This difference between plants and animals would be of fundamental importance if true in all cases, but recent experiments have shown that sodium chloride is just as necessary for many marine plants as it is for animals. It would not be surprising to find cases where sodium or chlorine are likewise necessary for land plants.

The condition in which the necessary substances exist in the soil has both practical and theoretical importance. In certain forms they are said to be "available" to the plant, in others not. A convenient method of determining quantitatively the substances which are "available" in a soil is one of the prime needs of practical soil study. In view of the difficulties with existing methods it would seem worth while to try to separate the available salts from the soil by means of an electric current.

[1] An address delivered at the Symposium on the Soil before Section G, American Association for the Advancement of Science, at Washington, 1911, the scope being limited to a brief presentation of elementary principles.

The chief process by which plant food becomes "available" is weathering, in which water and carbon dioxide play the chief rôles. The plant's supply of mineral salts as well as of carbon thus depends on the supply of carbon dioxide. The amount of this substance in the air is kept relatively constant not only by the production of carbon dioxide on the earth's surface, but by large amounts constantly escaping from its interior: and the ocean acts as a reservoir of carbon dioxide and a regulator of the amount in the air.

While the action of carbonic and other dilute acids benefits the plant by making plant food available, higher concentrations of acid may be injurious. As is well known, the acidity of the soil is a large factor in productiveness and some plants prefer acid soils while others show the opposite tendency. We are now in possession of a series of indicators which make it possible to ascertain various degrees of acidity found in soils without the labor of gas chain determinations, and these indicators may be used in the field.

An analysis of the factors of soil acidity is difficult on account of the many complications involved. Much aid may be expected from the application and extension of such careful quantitative studies as have recently been made on the ability of certain substances in solution to preserve the neutrality of the solution despite the addition of a considerable amount of acid or alkali to it.

To what extent the plant itself renders substances "available" by excretions from its roots is an unsolved problem. While it is generally agreed that the carbon dioxide excreted by the root is of importance in this respect, it is not certain whether other substances given out by the plant have a similar action. Investigation should be directed to the fatty acids which have been said by various observers to be excreted by the root. It is important to determine whether these substances are given off by the living or by the dead cells.

There can be no doubt that the bacteria of the soil help to render mineral food available by producing carbon dioxide. According to recent investigations the bacteria in one hectare of soil to the depth of 40 cm. produce yearly several million liters of carbon dioxide. Hence it becomes important in judging the fertility of a soil to test the amount of carbon dioxide which it produces under natural conditions.

The supply of available mineral salts is commonly augmented by the application of mineral fertilizers upon the theory that a deficiency in the supply of any necessary substance constitutes a "limiting factor" which retards the development of the crop. The addition of the deficient substance produces a great increase in the crop: the relation between this increase and the amount of salt added has been expressed by Mitscherlich in a simple formula having a constant which is independent of the yield. The constant for any given salt is called its efficiency value.

It is not my province to discuss this subject further and I will only mention that the application of one substance may set free a different one; for example, where magnesium is applied to the surface of the soil the roots at a lower level may receive, not magnesium, but calcium in soluble form (Hilgard). Sodium has been used in this way to set free potassium. Further study of this subject will doubtless bring to light facts of importance.

Some of the substances thus set free may exist in a loose combination to which the term adsorption has been applied. But it is clear that a variety of processes are included under this term. In the first place there are reversible processes, as when a

dye is taken up by filter paper and is then completely washed out again by water. The rational formula which has been developed by Arrhenius for this process merits mention here.

Another process commonly called adsorption involves chemical change. An example is seen in the taking up of fuchsin from a watery solution by carbon: the fuchsin can not be washed off again by water, but is readily removed by alcohol. In this case the dye has been changed from a substance soluble in water to one insoluble in water but soluble in alcohol, which indicates the formation of an isomeric substance.

In other cases we may obtain the characteristic adsorption curve and yet be able to explain the phenomenon as a chemical reaction which involves no adsorption.

Numerous reactions take place in the soil which give the adsorption curve. The most important adsorbing substances are colloidal materials. Although colloids play a very important rôle in the soil, the rapidly accumulating discoveries in the field of colloidal phenomena have as yet found little application in soil studies. The use of the ultra microscope and of ultra filters capable of sorting out various grades of particles too small to be seen with the microscope, as well as the methods for measuring the rate of diffusion, the osmotic pressure, the viscosity and electrical properties of colloids, should find a place in the study of soil colloids. And we may expect important results from the application of the principles derived from the study of gel formation, of hysteresis, of the analogues of the Danysz effect, of temperature coefficients, of reaction velocity and similar fundamental matters which have proved fertile in the study of colloids. To speak of these in detail would take too much time. I will therefore mention only one.

According to the Gibbs-Thompson law substances which lower the surface tension tend to become more concentrated in the surface and reactions which produce such substances are favored at the surface. In the soil we deal almost entirely with surfaces, and it will be seen that the operation of this principle must promote such processes as oxidation and reduction where they tend to reduce surface tension and to retard them in the opposite case.

In the production of colloidal substances the organic materials in the soil play an important part. The great value of these substances is shown by the fact that good soil can be made without sand or clay but not without humus: fresh volcanic ash, consisting of finely ground minerals capable of furnishing plant food, must nevertheless await the admixture of humus before it can support crops.

Organic substances may combine chemically or mechanically with plant food and thus prevent it from being leached out of the soil.

Certain organic colloids are known to have a remarkable power of keeping difficultly soluble salts in solution at concentrations far above those which are possible in pure water. This consideration may prove important in soil studies.

The study of the organic substances in the soil is in a very backward state. It is known that some are beneficial and others are toxic and that in some cases the toxicity is partly removed by simple oxidation.

This leads us naturally to a consideration of oxidation in the soil. It is a striking fact that while some plants take up unoxidized substances and gain the energy they need by oxidizing them the majority of plants must have their food in a highly oxidized form in order to make the best use of it. Thus CO_2 is a food while CO

is a poison: sulphates or nitrates are as a rule much better for the plant than the corresponding sulphites or nitrites. Most of the energy obtainable by oxidation of the latter substances is not available to the plant.

Thorough oxidation of the soil is one of the principal benefits of tillage and is a prime requisite for soil fertility: wherever it is interfered with by excess of water disastrous results follow, as may be seen in an extreme form in bogs. Investigations are being made on the oxygen content of bog waters and it is to be hoped that they may be extended to soil waters generally. Quantitative methods of estimating the rate of oxidation in soils under natural conditions are much to be desired.

The excretion of oxidizing and reducing catalyzers by living roots has recently been described and the statement has been made that the ability to oxidize such substances as gum guaiac (and to decompose hydrogen peroxide) is characteristic of good soil.

The study of catalyzers in the soil is a field in which we should have long since made a serious beginning. As I have just spoken of oxidation, an example from that field may be chosen to illustrate the point. It is well known that certain salts of manganese act as catalyzers which enormously increase oxidation, so much so that the minute traces of manganese which dissolve out from the glass vessels used in the experiment may affect the result. It is therefore possible that salts of manganese in the soil may affect fertility, and we may suppose that salts of iron and other substances may act in a similar way.

Another important field of study is found in the relation between those ions which are selected by the plant and those which it leaves in the solution. When the plant takes the K from a solution and leaves the Cl behind we have an illustration of this. The separation of positive from negative ions in this manner results in electric stresses which tend to bring the processes to a standstill. This may be overcome in two ways: first, the plant may give up to the solution some other positive ion in place of the K it takes in. It is evident that if such a process is taking place our usual view of the process of absorption neglects one of the most important factors of the process, and thus we should speak of an exchange rather than of absorption of ions.

On the other hand, we may find that along with every K ion the plant absorbs an OH ion derived from hydrolytic decomposition. If the plant should take the NO_3 ion and leave the Na we might find that along with every NO_3 ion the plant absorbed an H ion produced by hydrolytic decomposition. This amounts to saying that in all cases when the plant selects one ion and leaves the other it takes up the absorbed substance in the form of a very dilute acid or alkali. It is hoped that some investigations which are now going on may throw some light on this subject.

A further question concerns the manner in which ions which have been absorbed by the protoplasm are prevented from diffusing out again. It seems necessary to assume that only those ions which unite into undissociable compounds can be retained in the protoplasm. In this way we may explain how potassium, which presumably forms such compounds, may accumulate in the plant to a greater extent than sodium.

It may be pointed out that the chemical effects of soil substances on the plant may be of at least four kinds:

1. *Toxic Action.*—A large number of substances found in soils are toxic in sufficiently high concentration. This is true of both organic and inorganic substances.

It should be borne in mind that a concentration far too weak to affect one organism injuriously may be toxic for another. Concentrations of sodium chloride which are too low to affect certain flowering plants may be quite toxic to certain algæ and *vice versa*.

The study of such relations, especially in the case of organic soil substances, is now being carried forward.

2. *Stimulatory Action.*—A considerable number of toxic substances (including such salts as sodium chloride) exert at certain concentrations a stimulating effect on metabolism. It is quite possible that this belongs to the same category as the catalytic action of enzymes and of mineral salts. It also seems quite probable that the stimulating substances often play the rôle of kinases. How this may come about is illustrated by the germination of the castor bean. In this case it is necessary that the fat stored in the seed be split up by the action of an enzyme (lipase) but this can not act rapidly except in the presence of an acid (kinase). The rôle of the acid appears to be to cause the enzyme to swell and emulsify. The castor bean produces sufficient acid for this purpose, but it is clear that in other cases the kinase may be absorbed from without and may sometimes be furnished by another organism. There is reason to suppose that kinases include a great variety of substances, both organic and inorganic.

It is quite possible that stimulating substances may act in other ways, as, for example, by altering the permeability of the protoplasm.

3. *Nutrient Action.*—As was said in the beginning, we are not yet sure in all cases what nutrient substances are needed nor what their rôle is in the plant. To take but a single example we may select calcium. So important is it that we find plants classified ecologically into those which prefer lime soils and those which avoid them. A high authority very graphically describes how in the Mississippi Valley, in passing a region rich in lime to one where it is less abundant, the appearance of the trees changes: from being densely branched with thick foliage they become sparsely branched, so much so that the former region is avoided by squirrel hunters because the game can too easily hide in the dense tree tops. The crops become less and less, while barns and houses grow smaller as the soil grows poorer in lime.

Various hypotheses have been advanced to explain the effects of calcium. It was supposed to play an essential part in photosynthesis, but it appears that some of the lower green algæ may carry on photosynthesis in complete absence of calcium.

It was also supposed to form (in combination with proteid) an indispensable part of the nucleus, but many fungi and some of the algæ thrive without it, despite the fact that their nuclei and mitotic processes are apparently similar to those of plants which require calcium.

A more satisfactory view of this question is possible from the standpoint of protective action.

4. *Protective Action.*—It is well known that many toxic effects may be overcome more or less completely by the addition of other substances. When one substance thus acts as an antidote to another it is said to have a protective action. It is by no means necessary that the protective substance should itself be toxic, though it frequently is so; nor is it necessary that it should have any nutritive value. A large number of cases are now known in which mineral salts act as more or less efficient antidotes to other salts or to organic substances.

If we apply these principles to the case we have just now discussed, namely, the

rôle of calcium, we shall see that they clear up many puzzles. As long as we try to explain all the benefits of lime merely as nutrient effects we can not account for its special importance. But as soon as we learn that lime is extraordinary in its *protective* action, which greatly surpasses that of all other substances in the soil, its importance becomes self-evident. This protective action is so great that a single calcium ion acts as an antidote to from 20 to 100 ions of sodium, potassium, ammonium, etc.

To make clear that this result may be quite apart from its nutritive action it may be mentioned that lime is unnecessary as a nutrient for many fungi, and the ordinary nutrient solutions for these plants are made up without it. But if the concentration of the nutrient solution be too high it becomes toxic: then the addition of lime overcomes this toxicity, without adding any nutrient, and makes an extraordinary increase in the growth of the plants.

The great importance of protective action has led to a number of attempts to explain how it is brought about. It was early suggested by Loeb that one salt may prevent the toxic action of another by preventing it from entering the cell. This suggestion has not been put to decisive experimental test until recently. The outcome is extremely satisfactory: it may be illustrated by the following typical case. *Spirogyra* placed in 0.1 M NaCl solution quickly died, but it lived a long time if a very small amount of $CaCl_2$ was added (1 molecule of $CaCl_2$ to each 100 molecules of NaCl). In order to find out whether the calcium hindered the sodium from entering the cell, the plants were placed in a solution of NaCl strong enough to produce plasmolysis. On observing them continuously under the microscope the cells were seen to recover from plasmolysis, the protoplasm expanding so as to completely fill the space inside the cell wall. This could only be interpreted as due to the penetration of NaCl, which thus raises the osmotic pressure within the cell. But if the *Spirogyra* be plasmolyzed in a solution of NaCl containing a little $CaCl_2$ (1 molecule of $CaCl_2$ to 100 molecules of NaCl) the recovery takes 10 hours instead of the half hour required when it is in pure NaCl. It is therefore obvious that the penetration of the NaCl is hindered by the presence of $CaCl_2$.

The same thing is shown by experiments on *Laminaria,* in which the rate of penetration of the ions of NaCl is directly measured by electrical means. Here the addition of a very little $CaCl_2$ hinders the penetration of the ions of NaCl in the most striking way.

It may be asked how merely delaying the entrance of a salt produces a beneficial effect. It is a well-known phenomenon that the sudden addition of a salt may produce precipitation of a colloid when the slow addition of the same amount produces no such effect. Similar facts are familiar in biology. Moreover, there is good evidence that when NaCl finally begins to penetrate the cell in a mixture of NaCl + $CaCl_2$ the $CaCl_2$ enters along with the NaCl; it may thus hinder the NaCl from entering various internal cell membranes (such as the nuclear membrane). It may also have other effects on the protoplasm.

We may therefore conclude that the mechanism of antagonism consists primarily in hindering the penetration of toxic substances, just as calcium hinders sodium from entering the cell. That the calcium does this by directly affecting the plasma membrane is shown by a variety of evidence which can not be described here.

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THE ORGANIC CONSTITUENTS OF SOILS[1]

THE reports on the various phases of soil studies by the investigators who have preceded me in this symposium must have impressed you with the fact that the subject of the soil's fertility and infertility is by no means a simple matter of arithmetic, which involves only a few of the mineral constituents of the soil. It must also have become clear to you that the problem of the soil's fertility or infertility has not been solved by the application of these simple arithmetical means based on soil analysis or by the crop statistics accumulated in the years which have elapsed since Liebig first announced his views on soil fertility which gained for him for all time the title of "Father of Agricultural Chemistry." It is particularly gratifying to me, since I am to talk to you to-day on the subject of the organic constituents of soils, of their chemical nature and other properties, that Liebig is also known as the "Father of Organic Chemistry." To what tremendous proportions and significance in the world's industries and science this child of his (organic chemistry) has grown is familiar to all of you, and I assure you that Liebig, were he to return to-day, would be proud of its parentage. But I fear he would be displeased with his other child, as having made so little progress in the intervening years, although he started it in life strong and virile and full of promise. Up to a few years ago agriculture had not shared in the great impulses which modern science has given to other arts and industries, and the domination of the mineral requirement theory proposed in the first half of the last century and accepted without adequate proof of its validity is largely responsible for the lack of development in agriculture, commensurate with the enormous strides of other arts and industries under the guidance of modern scientific thought and research. But a new era of scientific inquiry is at hand and all phases of scientific endeavor are being applied to the solution of the problems connected with the soil's fertility and infertility—lines of scientific endeavor which were not even known to Liebig's time, but which to-day are well-recognized factors in soil fertility. I refer to soil bacteria, soil fungi, soil protozoa and other microorganisms, and all the biochemical functions of these, as well as of the higher plants, such as oxidation, reduction, enzymotic and catalytic, producing and destroying in the soil the organic constituents of which I shall speak presently. The soil is not simple, but complex. The soil properties and functions are likewise complex, not simple. All of the investigators preceding me in this symposium have emphasized to you by their papers how complex the subject is and how much remains to be done before a clear insight is obtained, but they have also shown to you clearly that a well-trained army of scientists is at work on the problems connected with soil fertility, applying thereto all the principles of modern science. The old view was simplicity itself; the soil was a mere trough in which the plant found its nourishment. But I can do no better than to let Liebig speak for himself. I quote from Letter XII. of his "Familiar Letters on Chemistry."

> A field in which we cultivate the same plant for several successive years becomes barren for that plant in a period varying with the nature of the soil; in one field it will be three, in another seven, in a third, twenty, in a fourth, a hundred years. One field bears wheat and no peas; another beans and turnips, but no tobacco; a third gives a plentiful crop of turnips, but will not bear clover. What is the reason that a field loses its fertility

[1] Presented at the Symposium on Soils at the Washington meeting of the American Association for the Advancement of Science.

for one plant, the same which at first flourished there? What is the reason one kind of plant succeeds in a field where another fails?

Liebig answered these questions by saying:

> Wheat, clover, turnips, for example, each require certain elements from the soil; they will not flourish where the appropriate elements are absent. Science teaches us what elements are essential to every species of plant by an analysis of their ashes. If, therefore, a soil is found wanting in any of these elements, we discover at once the cause of its barrenness and its removal may now be readily accomplished.

But has science removed the causes of the barrenness of a soil by the analysis of the soil or of the ashes of the plants? In this connection it might be well to quote a statement from an article by Coleman, which was awarded the prize of the Royal Agricultural Society of England in 1855. The author says:

> The causes which operate in producing the fertility or barrenness of soils have hitherto to a great extent been shrouded in mystery, not from any want of study, but owing to the difficulties which meet the inquirer at every step and the fact that most important results frequently depend upon causes which have eluded the search of the experimenter. The science of chemistry it was hoped would afford the key wherewith to unlock the mysteries of nature, but though its discoveries have conferred much practical benefit on the agriculturist, it has up to a very recent period effected comparatively little toward settling the cause of fertility or sterility. The theories of scientific men led us to expect that fertility depended upon the presence of certain mineral substances which were found invariably present in the ashes of plants, and the analysis of the soil it was believed would confirm the practical experience of the farmer; these hopes have been falsified except in the few cases of almost simple soils, such as pure clays and sands. In all other cases the analysis presented the existence in varying proportions of these substances supposed to induce fertility in the barren as well as in the fertile soil. The proportion of the various ingredients was next proposed as a sign of quality, but researches into the amount of inorganic matter abstracted by each crop have demonstrated that soils of a mixed character contain abundant supplies of mineral food for numerous crops.

This was over fifty years ago, and the statements made are practically as true to-day as they were then. There has been a marked advance in agricultural practise, but until quite recently comparatively little light has been shed upon the scientific principles which underlie these practises.

In all justness to Liebig, however, rather than to his followers, I must make another quotation from his works to show that he himself recognized the insufficiency of the views expressed by the above quotations. He says:

> But it has been observed that the crops are not always abundant in proportion to the quantity of manure employed, even though it may have been of the most powerful kind; that the produce of many plants, for example, diminishes in spite of the apparent replacement by manures of the substances removed from the soil, when they are cultivated on the same field for several years in succession.

From the above quotation it may be seen that Liebig recognized that there are many cases which his theory of mineral requirement failed to cover. Indeed, if he had followed the idea embodied in the quotation to its logical analysis he would have reached some conclusions similar to those presented to you in the various papers to-day.

Even before, and especially since, the time of Liebig, much material of the kind presented to you by the preceding speaker has been accumulated and handled in the same statistical manner. I should here say that much valuable information has been thus obtained, but it should be needless for me to add that even with all these years of crop statistics at hand the difficult problems of the cause of fertility or infertility of our agricultural lands have not been thereby determined nor eliminated, as

is again emphasized by what the other speakers have told you. The problem is not solved, though much progress has been made through the application of modern science. If the problem of soil fertility had been solved by the application of such statistics this symposium would not have been held. The pessimistic views expressed I can not share. Science is ever optimistic; the scientific investigator must above all things be optimistic and have an abiding faith that science will solve the intricate questions connected with his problem. The problem of soil fertility and infertility is broad enough and big enough for many workers and methods of attack. We can not all begin to unravel the tangled threads at the same point; there are different viewpoints and it is not improbable that some may have a keener vision than others to see the particular thread that will undo the snarl. The solution of the problem can only be reached through results of diligent experimentation, not by the statistics of even a hundred years. Criticism of the Bureau of Soils, similar to the present one, have recurred frequently in the past few years, as you are aware; but nevertheless the Bureau of Soils has continued its work from the new viewpoint and achieved some important results which throw much light upon the dark subject of the cause of fertility and infertility of our agricultural lands. I am very glad of this opportunity to present to you the results of a phase of this investigation, namely, the importance of the organic constituents of soils.

I have brought with me a tangible result of this work in the form of specimens of the organic compounds which have been found in soils. Their isolation and identification give definite information about a portion, and a very important portion, of the soil, the value of which has been recognized in practise, but about which no definite information was at hand, until this work was undertaken. By the application of modern methods of research to the intricate problems of the soil we have been able to throw such light upon the biochemical changes in soils that the old views of soil organic matter, soil humus and the process of humification are entirely overthrown. The compounds of which Mulder, the contemporary of Liebig, writes, such as humic acid, geic acid, ulmic acid, etc., terms which have appeared in text-books ever since, have absolutely no existence, but are shown to be mixtures of many different, and widely different, compounds. Not only were the compounds contained in these specimen tubes not known as soil constituents to Mulder or Liebig, but they were unknown to science at that time. With the advance of science since that time, especially of biochemistry, results such as these have been made possible. Some of these compounds contain only carbon and hydrogen; some, carbon, hydrogen and oxygen; some, carbon, hydrogen, oxygen and nitrogen; and some, carbon, hydrogen, oxygen, nitrogen and phosphorus. The compounds represent a great variety of chemical classes; there are paraffin hydrocarbons, hydroxyfatty acids and other organic acids, esters and alcohols, carbohydrates, hexone bases, pyrimidine derivatives, purine bases and pyridine derivatives. The individual compounds isolated or found are as follows:

ORGANIC COMPOUNDS ISOLATED AND IDENTIFIED

Hentriacontane,
Paraffinic acid,
Lignoceric acid,
Agroceric acid,
Monohydroxystearic acid,
Dihydroxystearic acid,
Resin,
Resin acids,
Resin esters,
Pentosan,
Phytosterol,
Liquid glycerides,
Picoline carboxylic acid,
Nucleic acid,
Cytosine,
Xanthine,
Hypoxanthine,
Adenine,
Histidine,
Arginine,

Pentose,	Choline,
Agrosterol,	Creatinine.

In addition to those here mentioned, a number of others are already isolated and will soon be reported. It is obvious that definite chemical information of this kind sheds much light upon the nature of soil organic matter and the processes going on in the soils. The compounds encountered are the same as those encountered in other lines of biochemistry and, therefore, the knowledge in regard to chemical relationships, origin and processes of change accumulated in such other lines can be directly applied to the understanding of the biochemical changes in soils and the constitution of soil organic matter. It is not my purpose to discuss the biochemical changes here other than to say, in passing, that the occurrence of these products which have an obvious chemical relationship with the great classes of tissue material contained in the plant and animal débris that gets into the soil, the carbohydrates, the fats, the proteins, the nucleic acids, the lecithins, etc., proves conclusively that the process of humification is not a mysterious process which takes place in soils only and can not be understood, but rather that the process of change in the soil is, after all, very closely paralleled by the processes known to take place in the laboratory when the complex organic substances are split by hydrolysis, oxidation, reduction or deamidization, into simpler derivatives. It is my purpose, however, to bring strongly before you the fact that these soil constituents affect plants directly.

As scientists personally interested in all that has to do with plant life and development, you will be glad to learn that we have studied as many as possible of these compounds in such a way as to determine what their possible function in the soil may be. Indeed, the reason why this investigation of the organic matter in soils was undertaken is to be found in the fact that certain soils and soil extracts behaved toward plants as if they contained something detrimental to crops rather than an absence or deficiency of the usual beneficial elements like nitrogen, phosphorus or potassium. This harmful effect on plant growth can be shown very readily by any one with such a soil under investigation. The soil is shaken with distilled water for several minutes, allowed to settle, and the supernatant liquid filtered off, which must usually be done with a Pasteur-Chamberland filter in an apparatus specially designed for such work, in order that all solid material may be removed. The clear filtrate is then used as a medium for the growth of wheat seedlings in bottle cultures. A control in pure distilled water, or in an extract from a fertile soil, should be run at the same time. In such cases the plants grown in the extract from the poor soil will show many peculiarities not shown by the plants either in the pure distilled water or in the extract from the good soil. The plant will be smaller, less developed in top and root, the latter often showing dark and swollen tips, which are sometimes bent into hooks, a phenomenon characteristic of certain toxic action. The growth in this soil extract may even be greatly less than the growth in the distilled water, although the soil extract naturally contains plant nutrients, whereas the distilled water contains none.

If a separate portion of the original extract be treated with carbon black, made from natural gas by imperfect combustion much as lampblack is formed on lamp chimneys, agitated and filtered, the filtrate will be a good medium for the growth of the seedlings. This simple treatment with carbon black has, therefore, removed by absorption the harmful properties of the

soil extract and the growth is now even better than in the distilled water.

Another experiment with soil and carbon black was made as follows: A layer of moist carbon black was covered with a layer of moist unproductive soil and this in turn by a layer of moist carbon black. In this experiment the moisture could circulate from the soil to the carbon black and back again and thus gradually the soil fluid would be freed of any injurious compounds by absorption into the carbon black. At the end of a day or two of this interaction the soil was freed from the carbon layers, plants were grown in it, and when compared with soil not so treated a very marked improvement was shown, again indicating that a harmful body was originally present and had been removed in whole or in part by this carbon black treatment.

Observations of this kind on many soils, together with a study of the properties of the material dissolved in the water, led to no definite isolation of the compound or compounds showing the harmful effect, owing to the fact that the quantities in the water extract are too small for identification, but they did lead to a recognition that the substances were not mineral in character, but were constituents of the organic matter of the soils.

That organic substances could produce such effects in such small quantities as must be present in soil solutions was not apparent from the literature and it became necessary to establish this point. With this in view, a test of about forty substances of organic origin which may get into the soil or be formed therein were tested, and it was conclusively shown that a number of these were decidedly harmful to plants, even in very dilute solutions comparable with the organic content of soil solutions.

It therefore became essential to make a study of the organic matter of the soil. The organic matter of the soil, however, was a subject about which the older chemistry of agriculture had much to say, but in regard to which modern science was discreetly silent. With no established facts and no methods of attack worked out, progress was necessarily slow at first, but gained speed with each compound isolated or identified until to-day there have been isolated in these laboratories more than twenty-five definite compounds from soil organic matter and the work is progressing at a rapid pace.

The search for this supposedly harmful constituent was rewarded by the discovery, among others, of dihydroxystearic acid, a compound which, on account of its frequent occurrence in soils, has been rather thoroughly studied in regard to its effect on plant development and growth.

The isolated and purified dihydroxystearic acid was tested by dissolving it in pure distilled water and it was found to have decided deleterious action on the wheat seedlings used in the tests. The acid prepared in the laboratory behaved in the same manner.

Its effect in the presence of nutrient salts was also extensively studied in solutions containing calcium acid phosphate, sodium nitrate and potassium sulphate, alone and in combinations of two and three of these salts, a total of sixty-six cultures being used in a single test. The injurious effect of the dihydroxystearic acid was less where all three of the nutrient elements were present than where only one or two were present. The injurious effect was least in those cultures of three nutrients where the nitrate was high. This indicates that the action of the nitrate tends especially to overcome the harmful effect of the

compound or else it enables the plant to resist or overcome its effect.

Dihydroxystearic acid has another effect which should here be mentioned as having a considerable bearing on its effect on crops, even in such soils as contain much plant nutrient material in the most readily available form. This is its influence on the absorptive power of the roots of the plants growing in the soil, the soil solution, or solutions of nutrient salts when dihydroxystearic acid is present in them. The absorption of potassium and phosphate was greatly interfered with, although both were present in soluble form in the culture solutions; only the nitrate was consumed in any quantity. This is in harmony with the fact stated above that when nitrates were plentiful in the solutions, the best growth was obtained and the effect of the harmful compound was minimized or entirely overcome.

The occurrence of dihydroxystearic acid was specifically studied. For this purpose soil samples of good and poor fields were collected and examined for this constituent. Soils from eighteen different states, extending from Maine to Oregon, and southward to Texas, of widely different origin, topography, texture, climate, drainage and cropping, varying from soils of the highest productivity to soils incapable of producing profitable crops, were examined for dihydroxystearic acid.

One third of all the soils examined showed the presence of this compound. It was found in virgin soils as well as in soils under long cultivation; in soils continually cropped as well as in soils under permanent sod; in soils from the Atlantic coast; in soils from the Pacific coast; and in soils from the gulf states. This compound is, therefore, a common soil constituent and is likely to be encountered in soils anywhere. Its formation or its accumulation is doubtless due to local conditions in any one section, but those local soil conditions are not confined to any region of the United States and probably not to any country or continent.

When the soils examined are separated into good and poor soils, as based on field observations, their relationship with dihydroxystearic acid is rather striking. Among the good soils only two contained dihydroxystearic acid and they were of only moderate productivity. Among the poor soils the number of those containing this compound was approximately one half. Of the soils which had a definite record for infertility, the dihydroxystearic acid was found in each and every case.

Judging from the foregoing relationships established by this investigation it would seem that dihydroxystearic acid is either a direct or indirect factor in the low productivity in soils; direct by virtue of its harmful effects on growing crops, indirect as an indicator of other compounds or conditions which cause soil to become less productive and even infertile. It is not possible to state from the data at hand that dihydroxystearic acid is the only factor which contributes to the infertility or unproductivity in those soils in which it was found, for it must be remembered that this is only one of many compounds, both organic and inorganic, harmful and beneficial, as I shall show presently, which exist in soils, any and all of which play a part in its relative fertility and infertility. It is certain, however, that the determination of even this one constituent leads to a recognition of the kind of infertility in the soils examined and is, therefore, a readily recognized symptomatic factor of poor soil conditions.

The isolation of harmful constituents is, however, only a part of the entire field covered by these investigations into the nature

and properties of soil organic matter, and I am very glad to be able to announce to you the existence in the soil of organic compounds decidedly beneficial to plant growth. Here is, for instance, a specimen of creatinine, a nitrogenous compound, which we have isolated from soils. This compound has always been associated with animal material, but in addition to finding it in soils we have also found it to exist in many plant materials, for instance, in wheat seeds, wheat seedlings, wheat bran, in rye, clover, alfalfa, cowpeas and potatoes, and if, as is suggested by several investigators, creatinine in the animal arises as the result of the breaking up of albumen, then it seems reasonable to expect that creatinine would be found in practically all plants. From the standpoint of root excretion I should also mention the fact that of samples of the same soil planted and unplanted, the planted soils give larger amounts of creatinine, thus showing that the increase of creatinine in the soil is connected in some way with plant growth. When the roots of wheat were bathed in water the creatinine could also be found in the culture water. One of the sources of creatinine in soils would, therefore, seem to be found in the presence of this compound in plants, since by the decay of plants and by direct sloughing or even by excretion, the creatinine is left in water and soil. Its occurrence in stable manure and also in green manures is another source, and its formation by soil organisms may be another. Whatever its source, it occurs in soils, and appears to be a normal and frequently occurring constituent and is present in amounts comparable with the amounts of soil nitrates found in ordinary agricultural soils. Its effect on plants, as I have implied earlier, is decidedly beneficial. When a series of cultures containing only potash and phosphates in varying proportions is set up together with another set containing in addition some fifty parts per million of the creatinine, the increased growth in the latter set is rather striking, fully comparable with the increased growth produced by nitrates under the same circumstances. When nitrates are present at the same time, the additional effect of the creatinine is not so marked, but an analysis of the culture solution reveals the fact that far less nitrates are used by the plants in the presence of the creatinine, although a larger plant growth takes place. In other words, the plants absorb the creatinine, make use of it in building up tissue, and in so doing a diminished draft is made on the supply of nitrates. It appears, therefore, that this soil constituent is fully as valuable as soil nitrate, can be present in amounts comparable to the amount of nitrate in soils and is able to replace the latter in its effect on plant growth. The significance of this to agricultural investigations is apparent.

Nor is creatinine the only constituent that behaves in this manner. The same beneficial characters are shown by other soil constituents, by the hypoxanthine and xanthine, by arginine and histidine and by nucleic acid. All these show the same beneficial character on plant growth and the same effect on the decreased nitrate consumption. Based on the results of these rather extensive investigations, I am ready to formulate the theory that these degradation products of protein are absorbed directly by the plant from the soil and that the plant uses these units for building up the complex proteins as far as it is possible to do so. Nitrate is usually considered as the best form of nitrogen for plant food. In order to use nitrate, a highly oxidized form of nitrogen, to form

the amido and imido groups of the protein molecules, a reduction must take place.

It is obvious that the plant must spend considerable energy in making this transformation. What is more reasonable than to suppose that the unit parts of the complex protein molecules, when presented to the plant, will be used by it in preference to expending labor on the nitrate to prepare these units? If a soil be liberally supplied with all of these units, it is conceivable that good plant growth will result, even without nitrate. If only a limited amount or kind of the units be present, the plant must have nitrates with which to supply the missing units. The knowledge, therefore, that such compounds exist in soils and play such a prominent part in the metabolism of the growing plant is of fundamental significance in soil fertility and gives a breadth of view to the subject which in its horizon can not be compared with the restricted vision imposed by the purely mineral requirement theory of Liebig, as this is used by his followers.

Nitrates are not produced in these cultures. Ammonia if formed is insignificant in amount, nor does ammonia produce the striking results shown by these organic compounds. There is a limit to the amount of any one of these soil constituents which the plant can profitably use and show increased growth. When a mixture of several of these units is presented at once, the growth is better than if an equivalent or even larger amount of any single one is presented.

These compounds are nitrogenous, but it must not be inferred that all nitrogenous compounds are beneficial to plant growth. Tyrosine, also a degradation product of protein, is distinctly harmful, and picoline carboxylic acid, isolated from soils, is moderately toxic. Guanidine, a compound not yet isolated from soils but whose presence is indicated, has also been rather thoroughly studied, and is decidedly harmful to plants, producing an effect on the cultures similar to that shown by certain plant diseases. The leaves become spotted with bleached dots, which spread and ultimately coalesce, producing a wilting of the plant and finally death. Not only is the guanidine harmful, in contradistinction to the beneficial nitrogenous substances just discussed, but it also differs from these compounds in its behavior when nitrates are present. The latter fertilizer ingredient very greatly increases the toxic action of this compound. This is especially striking when a large series of cultures with and without guanidine in the presence of many ratios of phosphate, potash and nitrate is set up and the cultures arranged according to the nitrate content. Both groups of cultures with and without guanidine will grow nicely for three or four days without any peculiarity being noticeable in either group. The cultures high in nitrates will be the first to show the symptoms of guanidine poisoning, and this effect will spread through the guanidine group of cultures, becoming more and more marked in those high in nitrates. At the conclusion of two weeks the group of cultures containing no guanidine will appear green and fresh, whereas the guanidine group appears bleached and wilted in all of the cultures containing nitrates. The cultures which contain no nitrate, that is, only potash and phosphate, are the only cultures which have been able to withstand the ravages of this poisonous compound. We have here a striking illustration not only of the harmful effect of an organic nitrogenous compound, but also an example of the increased harmful effect brought about by the addition of the otherwise so beneficial nitrate. This is in strong contrast to the ameliorating effect of ni-

trates over all other fertilizers in the case of the harmful soil constituent, dihydroxystearic acid. Guanidine is harmful and dihydroxystearic acid is harmful, although this manifests itself in a different way. Nitrate increases the harmfulness of guanidine, but decreases the harmfulness of dihydroxystearic acid. Here is an effect of a fertilizer which is entirely unexplainable from the viewpoint of mineral requirement or plant-food addition.

Nor is this behavior of nitrate in influencing the effect of these organic substances on plant growth and development the only illustration of the influence that different fertilizer salts can exert on the action of the organic compounds on plants. Cumarin is another substance which we have studied quite thoroughly in its effect on wheat seedlings. Besides decreasing growth, it also has a very peculiar and characteristic action on plants which enables the experimenter to pick out cumarin-affected plants at a glance from those affected by any other toxic body studied by us. The leaves are shorter and broader than is normal for wheat and only the first leaves are usually unfolded, the other leaves remaining wholly or partially within the swollen sheath. Such leaves as do break forth are usually distorted and curled or twisted. Now when cumarin is contained in the culture solutions of the various fertilizer salts, it is quite apparent that neither nitrate or potash nor combinations of these affect these characteristic symptoms of cumarin poisoning, but the slightest addition of phosphate causes a very decided change in the appearance of the plants, which increases with increasing phosphate until nearly normal development is obtained, as shown by comparison with the corresponding cultures without cumarin.

I must also cite to you the influence of quinone when similarly studied. The effect of quinone is decidedly different from the effect of cumarin, which produced short, broad, irregularly developed leaves and stunted tops; the effect of quinone is to produce long thin leaves, and tall slender plants. The interesting part in this connection, however, lies in the fact that the growth in the cultures high in potash was nearer to the normal than the growth in either the mainly phosphatic or mainly nitrogenous cultures, and was in fact poorest in the latter. Vanillin similarly studied behaved like the dihydroxystearic acid in that nitrates were the most efficient aid to counteract its harmful effect on plants.

These experimental facts present much interesting material for discussion from various points of view, but I wish here only to call your attention to the relations between organic compounds, their effect on plants, and the action of fertilizers in this connection, which action is apparently apart and in addition to any food value of the fertilizer salts for plants in the usually accepted sense. It is clear that in the illustrations which I have here given you, the various fertilizer salts acted differently in overcoming the respective harmful effects of these toxic organic compounds. The mainly phosphatic fertilizers were the most efficient in overcoming cumarin effects; the mainly potassic in overcoming the quinone effects; the mainly nitrogenous fertilizers in overcoming the vanillin and dihydroxystearic acid effects; and in the case of guanidine, the mainly nitrogenous fertilizers even had the effect of increasing the harmfulness of this compound. It is clear that the organic compounds in soils, whether already isolated and studied or yet to be found, are potent factors in soil fertility as they have a direct effect on plant growth and plant metabol-

ism and on the action of fertilizers. These actions of the different fertilizer combinations or different fertilizer requirements, as they may be styled, show a certain parallelism with field observations on soils and their fertilizer requirements, and one is tempted to ask to what extent the different fertilizer requirements of different soils, or of the same soil under different conditions, may be influenced by the same cause. That harmful bodies occur in soils has been amply shown and that these are influenced directly or indirectly by fertilizer salts is also clear from these and other researches. That the constitution of the organic matter varies from soil to soil and in the same soil under different conditions of aeration, drainage and cropping is likewise clear. The presence of compounds inimical to plant growth by virtue of a property resembling that of any of the above-mentioned substances might, therefore, cause a different fertilizer requirement, a requirement which might even change from time to time, according to the nature of the biochemical relations producing the body or according to the nature of the plant remains in the soil; in other words, according to the rotation, with its necessarily altered soil management, and the altered biochemical changes produced in the different plant remains.

The soil has vital functions. The soil can not be considered as the dead, inert remains of rocks and previous vegetation, but must be considered as an accumulation of such material in which the process of formation, alteration and transposition are still at work. In other words, the soil in its entirety is not dead or inert, but endowed with functions analogous to those of life itself. In it take place the same processes of solution and deposition that have taken place in past ages, and are taking place to-day in the geologic processes connected with the action of the water on the rocks and minerals of the earth's crust. In it take place the same physical and chemical interactions as take place in the movement of subsurface waters generally, resulting in ore formations or depositions. In it take place the same processes of fermentation, digestion, or decay of organic materials as take place in animals and plants or in the production of industrial products, such as cheeses, wines and beers, brought about in the soil as in these other processes by means of ferments, enzymes, bacteria and fungi or molds. In it take place the same processes of oxidation and reduction which play so enormous a part in all life processes, and these researches have shown the nature of compounds in the soil organic matter to be the same as those derived from such life processes or from similar laboratory processes of digestion, oxidation or reduction. Organic matter is very changeable; it is the material which forms the food, as it were, of all the microorganisms of the soil, of the bacteria, of the molds, of the protozoa, and influences them favorably or unfavorably, just as the higher plants are affected. In turn these agents are great promoters of these changes in the organic débris of soil. All of these processes and the life forms in the soil are affected by fertilizer salts when added to the soil, and changes are produced in the soil, physical, chemical and biochemical, which influence the soil and affect its potential fertility entirely irrespective of the added plant food. In other words, the soil has been changed in many prominent characteristics even before any crop is planted therein.

I must not leave this subject of fertilizer action, in view of the preceding paper, without saying that the Bureau of Soils takes an advanced stand not only on the present use of fertilizers, but on their ex-

tension in agriculture, in spite of the reiterated statements to the contrary. The point of difference lies in the explanation of their action, the one view being that they are merely so much plant food which must replace the removal by crops, the other being that in addition to any plant food value which they possess, they affect the soil and produce changes and influences such as are at least partially illustrated by the experimental results cited here. We believe that these additional—note particularly that I say additional—actions explain more fully the function of fertilizers in agriculture. From the former view the application of fertilizers would be restricted to poor and so-called exhausted soils and poor systems of agriculture; from the latter viewpoint, fertilizers are indicated as well for fertile as for infertile soils, as an adjunct to successful farming and bringing the soil to its highest capacity of crop production.

The action of fertilizers on soils is a much contested question, but the weight of evidence is against the assumption that their effect is due altogether to the increase of plant food as such. If so simple an explanation were the true one, nearly a century of investigation of this problem by scientists of all civilized nations would surely have produced greater unanimity of opinion than now exists in regard to fertilizer practise. Thoughtful investigators everywhere are finding that fertilizer salts are influencing many factors which contribute toward plant production besides the direct nutrient factor for the plant. It is this additional influence of fertilizers which makes them doubly effective when rightly used and inefficient when improperly used. To this influence of fertilizers on soil and biological conditions is due their capriciousness when applied on the theory of lacking plant food, and any study which throws further light upon the mooted question is of direct help toward reaching that view of soil fertility and soil fertilization which will eventually result in a more definite, more rational and more remunerative fertilizer practise than in the past, and thus bring about the more extensive use of fertilizers in agriculture.

OSWALD SCHREINER

BUREAU OF SOILS,
WASHINGTON, D. C.

THE DRIFT IN SECONDARY EDUCATION

IN the course of a preliminary study of the conditions affecting a particular high-school subject, I have been led to glean from the reports of the Commissioner of Education data which, tabulated or represented graphically, may have a certain interest.

The table has to do with the expansion of secondary education, 1890–1910. It is self-explanatory, but one or two points in it may be noted. First, while the population of the continental United States has increased 50 per cent. the proportion of the population in the secondary schools has been multiplied by about *three*. Second, that while the proportion of students completing the secondary course and graduating has slightly but decidedly increased, the proportion of them preparing for college, either classical or scientific courses, has been diminished by about 60 per cent. Third, that the proportion of boys in the secondary schools has in twenty years not varied much from 44 per cent.; also, that the proportion of boys in the successive years falls off somewhat, but not as largely as I had been supposing; in fact, the "elimination" of girls goes on at almost as rapid a rate as that of boys. Finally, that while the amelioration of conditions as shown by the number of students per teacher is noticeable, the burden placed upon the teacher in small high schools is in this respect markedly less than in those in cities of 8,000 inhabitants or more, and in these small schools the improvement is much greater. Of course, specialization in teaching tends in some degree to counteract this.

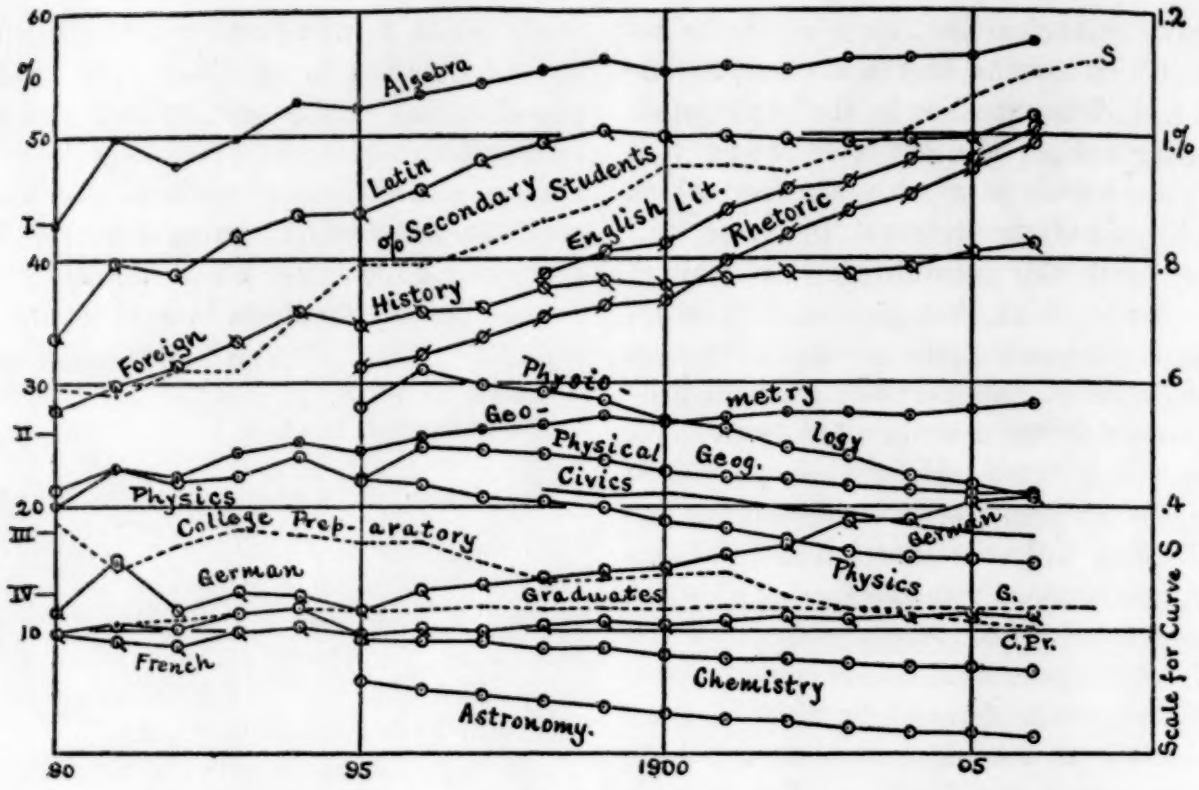

Chart I.

THE EXPANSION OF SECONDARY EDUCATION[1]

	1890	1900	1910
Population of U. S., millions	62.622	75.063	91.972
Number of public high schools reporting	2,526	6,005	10,213
Number of other sec. schools reporting	1,632	1,978	1,657
Number of secondary pupils	367,003	719,241	1,131,466
Percentage of boys, secondary pupils	45.03	43.16	43.97
Percentage of population, sec. pupils	0.59	0.95	1.23
Percentage of high school pupils, urban	—	45.3 (1906–7)	47.3
Percentage of high school pupils, yr. I	—	(42.35)	42.09
Percentage of these boys in yr. I	—	(44.2)	45.6
Percentage of high school pupils, yr. II	—	(27.23)	27.10
Percentage of these boys in yr. II	—	(42.6)	43.3
Percentage of high school pupils, yr. III	—	(18.17)	18.18
Percentage of these boys in yr. III	—	(41.6)	41.8
Percentage of high school pupils, yr. IV	—	(12.25)	12.63
Percentage of these boys in yr. IV	—	(40.2)	39.7
Percentage secondary pupils graduating	10.05	11.74	12.18
Percentage of these boys	—	—	40.3
Percentage preparing for College	18.66	14.53	6.80
Urban high schools—number	—	691	838
(In cities of 8,000 or over.)			
Teachers per school	—	11.4	19.0
Students per school	—	340.3	516.3
Students per teacher	—	29.9	27.1
Rural high schools—number	—	5,314	9,375
Teachers per school	—	2.4	2.7
Students per school	—	53.5	51.5
Students per teacher	—	22.7	18.8

[1] Extracted from the reports of the Bureau of Education.

Chart I. gives graphically the history of the decline in scientific studies as compared with humanistic, from 1900 to 1906. It was accidentally omitted from its proper place as illustrating a previous article.[1] Besides showing this decline in a striking way, the dotted curves show also the facts about the proportion of secondary students to population, and the proportion of graduates and college preparatory students to the whole mass of students. The points marked I., II., etc., at the left, indicate the approximate proportions of secondary students in the first, second, etc., years of the course. The decline of science indicated up to 1906 is continued in 1910, though not plotted.

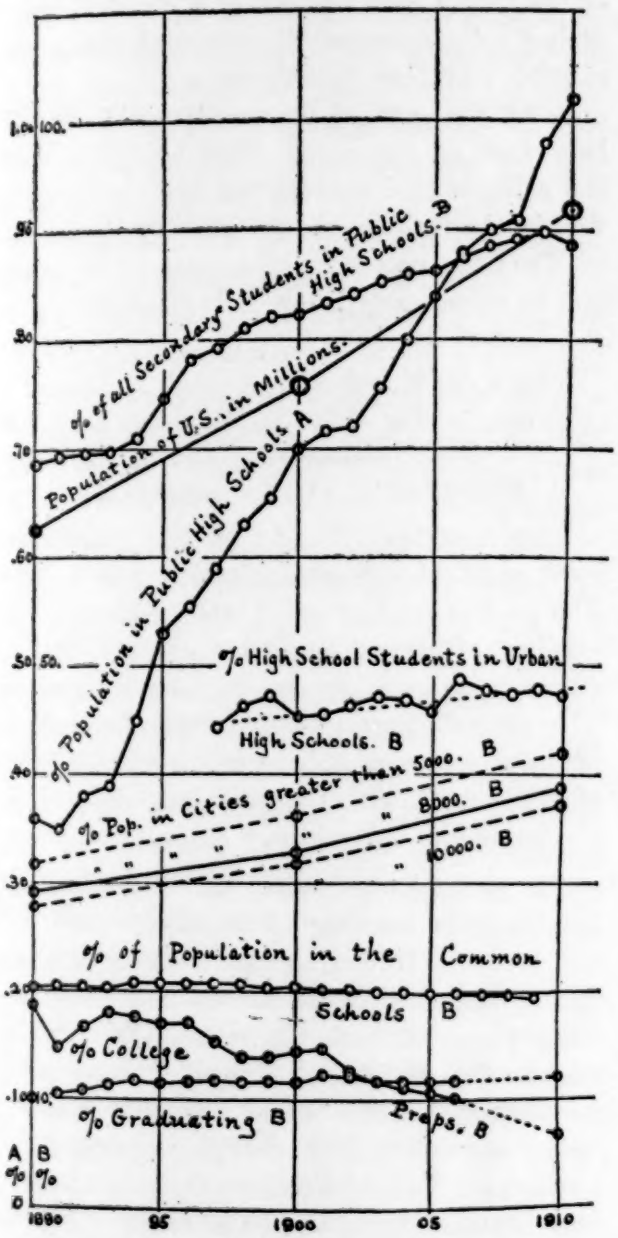

CHART II.

Chart II. is for the most part self explanatory. It shows again the facts about population, graduates and college preparatory students, and adds data about some other interesting relations. The highest curve of all shows the extent to which public high schools are monopolizing the work of secondary education. The curve for per cent. of population in the common schools shows that, contrary to the tendency in secondary education, this ratio tends to diminish, though not varying much from 20 per cent. But the group of curves relating to urban high schools and urban population develops a fact of considerable interest. The two dotted curves are taken from census data; the heavy curve between them is partly interpolated. They give the proportion of urban to total population. The curve above them shows what proportion of the high-school population attends school in places of 8,000 or more. This latter proportion has increased irregularly from about 44 per cent. in 1897 to a little over 47 per cent. in 1910. This is clearly seen to be less than the rate of increase of urban population, so that in some fifteen years the cities of 8,000 or over will have only their share of the high-school population—the country high schools are catching up to the city. Of course the drift toward industrial education will certainly largely modify our classifications in the next decade; but in what way can not now be concluded.

Chart III. shows to what extent we may find local influences hidden under general averages. The data are taken from the report for 1910. The black dots are points representing conditions in the old slave states; the crosses stand for the New England states —no longer *Yankee* states. The dotted lines represent averages for the United States. The plotted points group themselves so as to show, as no table could, that where the number of secondary students per thousand of population

[1] SCIENCE, 35, p. 94, 1912: "Is Science Really Unpopular in High Schools?"

is small, there the proportion of secondary students pursuing algebra tends to be large. One is reminded of Booker Washington's remark about the freedman's penchant for studying Latin and holding office—but the

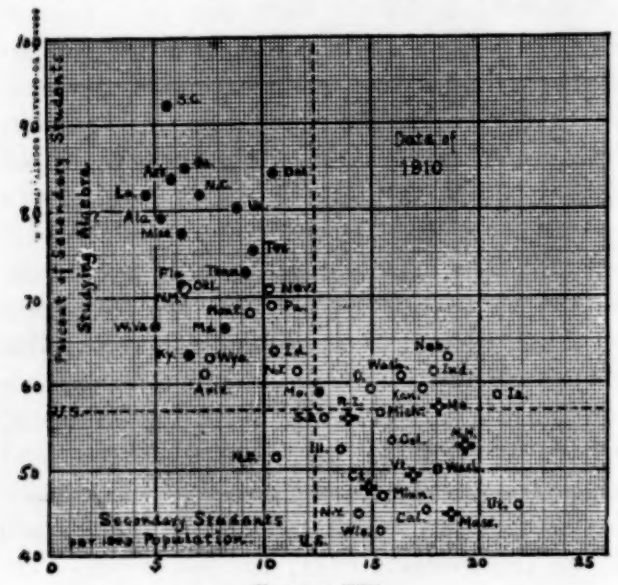

CHART III.

black dots on the chart represent mainly white education.

The method of this last chart may be applied as well to other studies and to the percentage strength of the various years of the course, all of which are shown to be more or less strongly related to the number of students per thousand of population. An attempt to correlate these statistics with urban congestion has, however, failed, as urban density so crosses state educational systems, and counts for so much more in some states—as Rhode Island—than in others, that a satisfactory disentanglement of the relations is practically impossible.

I would draw one general conclusion from this study. Our impressions of secondary—and other—education are strongest as they are derived from our own experience as students. Most college and university men, even those who have the closest relations with the work of the secondary schools, have done little actual secondary school teaching, and hence are very likely to be strongly under the influence of impressions received twenty, thirty or more years ago. Such impressions are, however, nearly valueless as guides in dealing with the present situation. The tabular and graphical representations of statistical facts show at a glance that since 1890 the problem of the secondary school has changed from that of the fitting school to one of a decidedly non-fitting school—some bigots would say a decidedly *unfitting* school; a school in which only 6.8 per cent. of the pupils anticipate college work of any sort. This being the case, the colleges and universities can not lead the way in the fashion of 1892 and the Committee of Ten; the problems of secondary education can be solved only in the schools.

WILLARD J. FISHER

ITHACA, N. Y.,
June, 1912

SCIENTIFIC NOTES AND NEWS

THE American Society of Naturalists will meet at Cleveland on January 1 and 2, 1913. The session on January 1 will be given to the reading of papers on genetics, and that of January 2 to a symposium on adaptation. The annual dinner, open to members of the affiliated societies, will be held on the evening of the second, with the president's address by Professor E. G. Conklin.

THE American Society of Zoologists will hold a joint meeting of its eastern and central branches in conjunction with the meeting of the American Association for the Advancement of Science at Cleveland, Ohio, during convocation week. Notice of this meeting, together with a request for the titles of papers to be presented, will shortly be sent to all members. Communications from members of both branches should be addressed to Professor Winterton C. Curtis, University of Missouri, Columbia, Mo., the secretary of the Central Branch, since the constitution provides that "the meetings of the societies shall be arranged for and conducted by the officers of that branch in whose territory the meeting is held." The president of the Central Branch during the current year is Professor Henry B. Ward, of the University of Illinois, Urbana, Ill.

A JOINT meeting of the American Anthropological Association, the American Folk-Lore Society and Section H of the American Association for the Advancement of Science will be held in Cleveland, Ohio, on December 30, 1912, to January 4, 1913. Titles of papers to be read and abstracts of the same should be sent by December 1 to Professor George Grant MacCurdy, Yale University Museum, New Haven, Conn., who is responsible for the joint program.

THE Association of American Universities will hold its annual meeting at the University of Pennsylvania on November 7, 8, and 9, 1912.

PROFESSOR BERGSON, of Paris; Professor De Vries, of the University of Amsterdam, and Sir William Ramsay, of London, have been appointed Woodward lecturers at Yale University.

DR. FELIX KRUEGER, professor of philosophy and psychology at Halle, who is this year's Kaiser Wilhelm professor at Columbia University, delivered his inaugural lecture on October 29. His subject was "New Aims and Tendencies in Psychology."

PROFESSOR EMILE BOREL, director of scientific studies at the École Normale Supérieure and professor of the theory of function at the University of Paris, will lecture at Princeton University on November 6.

PROFESSOR JORGE ENGERRAND, of the City of Mexico, has been designated honorary professor in the New University of Brussels. The Mexican government has appointed him to the directorship for 1912–13 of the International School of Archeology and Ethnology, recently founded in the City of Mexico. In this latter capacity Professor Engerrand's work will deal largely with the antiquity of man in America and especially from the geological standpoint.

PROFESSOR JOHN E. SWEET, formerly professor of practical mechanics in Cornell University, was eighty years old on October 21, and some of his former students gave him a banquet at the Onondaga Hotel in Syracuse on that night.

DR. MAZYCK P. RAVENEL, head of the state hygienic laboratory at the University of Wisconsin, has been appointed first lieutenant in the medical reserve corps of the United States Army by President Taft.

AT the Nutrition Laboratory of the Carnegie Institution Dr. Raymond Dodge, professor of psychology at Wesleyan University, Middletown, Conn., has been appointed consulting experimental psychologist, and an especial laboratory has been equipped for his investigation. Dr. Sergius Morgulis, Sheldon fellow of Harvard University during the year 1911–12, and who has engaged in investigation in the laboratory of Professor Zuntz, of Berlin, has been appointed associate in animal metabolism.

M. F. SMITH, B.S. (Yale, '97), has been appointed assistant astronomer at the Yale University Observatory.

DR. CHARLES PORTER SMALL, who has been the university physician since the founding of the University of Chicago, has resigned to devote his entire time to private practise.

AT the last meeting of the Rumford Committee of the American Academy of Arts and Sciences a grant of $250 was made to Mr. W. O. Sawtelle, of the Jefferson Physical Laboratory, Harvard University, in aid of his research on the spectra of the light from the spark in the oscillatory discharge.

PROFESSOR WM. T. MAGRUDER has resumed his duties as head of the department of mechanical engineering in the Ohio State University after a year's leave of absence. Professor Magruder spent a considerable part of the year in travel through Europe, investigating the trades schools. He has recently been elected president of the Society for the Promotion of Engineering Education.

THE Rev. José Algué, director of the Manila Observatory, P. I., is now in this country and is making his headquarters at Georgetown University, of whose observatory he was formerly director.

DR. KRUSIUS, dozent at Marburg, has undertaken, with the support of the Prussian and

Bavarian governments, a ten-months' trip to foreign countries, to repeat on different races the investigations on myopia in the schools which he began some time ago in the province of Brandenburg.

Mr. S. W. Foster, who for the past six years has been engaged in deciduous fruit insect investigations for the U. S. Bureau of Entomology, is now engaged in the research and applied work on the Pacific Coast with headquarters in San Francisco.

Mr. Robert C. Murphy is in charge of an expedition to the South Georgia Islands, under the joint auspices of the Museum of the Brooklyn Institute of Arts and Sciences and the American Museum of Natural History.

Dr. Rollin D. Salisbury, head of the department of geography and dean of the Ogden Graduate School of Science in the University of Chicago, went into camp about October 1 at Lake Nahuel Huapi, Patagonia, in the eastern Andes in latitude 41°. On his return he expects to stop at Rio de Janeiro and go back into the interior from that point to the great iron deposits of Brazil. Professor Salisbury will resume his work at the University of Chicago at the opening of the winter quarter, 1913.

Dr. W. J. G. Land, assistant professor in the department of botany at the University of Chicago, has sailed from San Francisco for a collecting trip in the islands of the southern Pacific. His course includes the Hawaiian, Tonga and Fiji Islands, and Australia. The object of the trip is primarily to observe and collect liverworts, and incidentally to collect interesting forms of other plant groups.

At the meeting of the Minnesota Pathologic Society at the university on October 15, the annual address was delivered by Dr. Ludvig Hektoen on "Recent Observation of Streptococci and the Streptococcal Infection."

"Problems of the Modern City" is the subject of a series of lectures being given by present and former professors of the University of Chicago in Fullerton Hall, of the Art Institute, Chicago, from October 15 to December 17. The course was opened by J. Paul Goode, associate professor of geography, who spoke on "The Dynamics of the City: Its Geography and Transportation." Robert Franklin Hoxie, associate professor in the department of political economy, followed with a lecture October 27 on "The Development of Industry and the Social Problems of a City." "The Health of the City" was the subject of a lecture by Edward Oakes Jordan, professor of bacteriology, on October 29.

Last year there was a decrease in the production of tungsten ore owing to the decrease in the demand for tool steels, in which the bulk of the tungsten produced is used, according to Frank L. Hess, in a report on this metal just issued by the United States Geological Survey. The production of domestic tungsten ore in 1911 amounted to 1,139 short tons of concentrates, carrying 60 per cent. of tungsten trioxide, valued at $407,985; in 1910 the production amounted to 1,821 short tons, valued at $832,992. Tungsten is used chiefly in making steels that will hold their temper when heated, but it is most generally known as supplying the filament of tungsten incandescent lamps. The great improvements in drawing tungsten wire and further notable improvements in the size of the globe of the tungsten lamp and in other mechanical details that add greatly to its efficiency are making it encroach upon the carbon-filament lamp and the arc lamp, and it is rapidly driving from the market the tantalum lamp, which was the first good incandescent lamp having a metallic filament. Diamonds are used for dies in drawing tungsten wire. At first it did not seem possible to drill small enough holes through the diamonds to make wire sufficiently fine for lamps of small candlepower, but wire 0.0006 inch in diameter can now be drawn in quantity. The total quantity of tungsten ore used for electric lights, however, amounts to only a few tons a year. New uses of tungsten, in making electric furnaces, electric contacts and targets for Röntgen rays, have been developed, and the last two products are being actively manufactured.

UNIVERSITY AND EDUCATIONAL NEWS

MR. J. PIERPONT MORGAN has given $200,000 to Trinity College for the erection of a library and administration building.

MR. JAMES B. BRADY, of New York City, has given $200,000 for the establishment of the Urological Institute at the Johns Hopkins Hospital. He has also undertaken to provide an endowment for the institute.

THE sum of $60,000 has been given by an anonymous New York citizen toward the $800,000 which Smith College is undertaking to obtain in order to receive $200,000 from the General Education Board.

THE new library building of the Ohio State University, built at a cost of $250,000, is nearing completion. While an additional appropriation will be needed to complete the equipment, the greater part of the library, which consists now of more than 115,000 volumes, will be moved into the new building within a few weeks.

WORK on the stone foundation of the new University of Illinois armory is well under way. The interior dimensions of the armory will be 200 by 350 feet. The building under construction is not the complete building, but merely the drill room.

ST. LOUIS UNIVERSITY is building an addition to the Medical School, which will accommodate the offices and library and new laboratories for animal experimentation. It will cost about $10,000.

THE dean of Johns Hopkins Medical School announces that it has become necessary to limit the number of students owing to the limited space and facilities in the various laboratories. The present enrollment is 355, the largest in the history of the school, and fifty other students were refused admittance prior to the beginning of the session.

THE enrollment of students in the Ohio State University this year is 3,243, of whom 780 are in the College of Engineering.

SEVERAL members of the faculty of Western Reserve University will receive in certain special classes, during the semester October, 1912, to February, 1913, men and women who are teachers of the high schools and other schools of Cleveland and vicinity, and others interested in such courses.

THOMAS WINGATE TODD, M.B., Ch.B., F.R.C.S., at present lecturer in anatomy at Victoria University, Manchester, England, has been appointed Henry Willson Payne professor of anatomy in the medical department of Western Reserve University. Professor Todd will take up his duties at Cleveland about December 10.

DR. CHARLES LINCOLN EDWARDS has been appointed professor of embryology and histology in the medical department of the University of Southern California, and has been made director of the department of nature-study in the Los Angeles public schools.

THE Ohio State University, Columbus, has the following new members in the faculty of the College of Engineering: Forrest K. Pence, professor of ceramic engineering; A. E. Flowers, professor of electrical engineering, and R. A. Brown, instructor in electrical engineering. The following members have been promoted to the rank of professor: Homer F. Staley, ceramic engineering; James R. Withrow, chemistry; Robert F. Earhart, physics; Frederic C. Blake, physics; Samuel J. Barnett, physics, and Edwin F. Coddington, mechanics.

THE following changes have been made in the faculty of the New York State Normal College at Albany: Dr. Leonard A. Blue, formerly professor of education at Goucher College, has been appointed dean and professor of education in place of Dr. William B. Aspinwall, who resigned to become principal of the State Normal School at Worcester, Mass.; Dr. George S. Painter has been appointed professor of philosophy and psychology to succeed Professor Alfred J. Rejall, now assistant in psychology at Columbia University; Professor Herbert M. Douglass, formerly of Cornell University, has been appointed instructor in mathematics and mechanical drawing.

THE following recent appointments in St. Louis University School of Medicine have

been made: John Zahorsky, M.D. (Missouri Medical College), professor of children's diseases; Paul M. Carrington, M.D. (College of Physicians and Surgeons, Baltimore), of the Marine Hospital Service, professor of hygiene; Joseph Grindon, M.D. (St. Louis Medical College), professor of dermatology; George Ives, M.D. (Johns Hopkins University), assistant professor of bacteriology; A. M. Brown (Washington University), instructor in biology.

The School of Botany of the University of Texas announces the following changes and promotions: Dr. F. D. Heald, professor of botany, resigned to become pathologist to the Chestnut Tree Blight Commission of Pennsylvania; Dr. I. M. Lewis, promoted from instructor to adjunct professor; Dr. Frederick McAllister, instructor in botany, Cornell University, appointed instructor; Mr. Charles H. Winkler appointed by the board of regents to act as chairman of the school faculty for the term of two years.

DISCUSSION AND CORRESPONDENCE

AN ELECTROMOTIVE FORCE DUE TO MECHANICAL ACCELERATION

To the Editor of Science: From well-known mechanical principles it follows that when a solid body is given an accelerated motion each particle of the body is acted upon by a force having a direction opposite to that of the acceleration. In magnitude this force is equal to the product of the acceleration and the mass of the particle.

Applying this to the modern conception of "free electrons" in metals, it is clear that when a piece of metal is given an accelerated motion each electron within it should experience a force tending to move it and this force will be equivalent to an electromotive force. The magnitude of the latter is easily calculated.

The equivalent electromotive force in volts per cm. is

$$V = \frac{300a}{\left(\frac{e}{m}\right)},$$

where V = volts per cm.

e = charge of an electron in electrostatic units.

m = mass of electron.

a = the acceleration given to the metal.

That this equivalent electromotive force is not too small to be detected with appropriate apparatus can readily be shown. If a coil of wire is caused to oscillate rapidly about its own axis, for instance, the electromotive force of each turn is added to that of the next and thus the effect can be enormously magnified over what it would be in the case of one turn. An alternating electromotive force should be generated which when commutated would be within the range of a good galvanometer.

Whether the result of such an experiment were positive or negative it would be of great interest for modern theory, for in case it were positive it would give *directly* the *value* of e/m for the electrons within a metal, and if it were negative it would clearly indicate the falsity of some part of the modern theory.

The apparatus for such an experiment has been for some time in process of construction and I hope before long to report on the results.

D. E. Comstock
Massachusetts Institute of Technology,
September 25, 1912

REVERSION OF AMBLYSTOMA

To the Editor of Science: The following note on the reversion of adult *Amblystoma*, to the larval axolotl stage, may be of interest to students of amphibia.

A number of years ago, when the writer was a boy residing at Colorado Springs, he confined some "water-dogs" (*Amblystoma*), for a period of four or six weeks, in an artificial pool of water of small diameter. The pool was so fenced that the animals were unable to escape, though they repeatedly endeavored to do so. This enforced residence in the water seemed to effect in them a distinct transformation; the color became duller, the tail broader, the head assumed a more triangular form, and back of the head on each side of the neck, there appeared small, bluish knobs. These

increased in size and became soft, slender, conical protuberances of bluish color, and about five eighths of an inch in length. These became the framework of a growth of a moss-like gill structure, that covered them completely. When these changes were complete, the "water-dog" had assumed the form familiar to the writer, and known to be the axolotl. This animal he had regarded as distinct from the "water-dog," and the apparent identity of the two animals impressed him greatly. Later he secured a publication concerning this, to him, amazing transformation; but the transformation therein described was of the reverse order, or from the axolotl form to that of the "water-dog." As the writer shortly after removed to the east, he had no opportunity of repeating the experiment, and finally dismissed the matter from his mind. If the facts here detailed have not been hitherto recorded, it would be interesting if some one would repeat this experiment, which is a too distant memory to be submitted as a scientific demonstration.

R. D. O. JOHNSON

NOTE ON THE LIFE HISTORIES OF THE FERN RUSTS OF THE GENUS UREDINOPSIS

UNDER *Peridermium balsameum* Peck the writer[1] described experiments and observations which indicated that the fern rusts belonging to the genus *Uredinopsis* are heteræcious, having their æcial stage on *Abies balsamea* (L.) Mill. Artificial infection experiments carried on during the present season by the writer have established the conclusions there stated. These experiments have shown that *Uredinopsis Osmundæ* Magn., *U. Struthiopteridis* Störmer, *U. Phegopteridis* Arthur, *U. mirabilis* (Peck) Arthur, and *U. Atkinsonii* Magn. have their æcial stages on *Abies balsamea* (L.) Mill. The æcia are the white spored forms that have passed as *Peridermium balsameum* Peck. A detailed description of the experiments will be published soon.

W. P. FRASER

MACDONALD COLLEGE,
QUEBEC

[1] *Mycol.*, 4: 189, 1912.

"PAWLOW"

I NOTE with interest Professor Halsted's protest[1] against the spelling of Lobachevski's name with a "w," a sort of scientific Wellerism which Teutonic influence has foisted upon the English language. Is it too much to hope that some day we may find American physiologists referring to Pavloff instead of to Pawlow, or is it true that in such mixed crosses, as the heredity experts would say, German pedantry is prepotent over common sense?

J. F. ABBOTT

SCIENTIFIC BOOKS

Non-Euclidean Geometry. A critical and historical study of its development. By ROBERTO BONOLA. Translated by H. S. CARSLAW. Chicago, The Open Court Publishing Co. 1912.

To Dr. Paul Carus the world is greatly indebted for making this book accessible in the universal language, English.

There are two ways of envisaging the coming of non-euclidean geometry; either as a gradual development or as a saltation. The first attitude is taken in my article, "The non-euclidean geometry inevitable";[1] the second in the introductions to my translations of Lobachevski and Bolyai, where I say Lobachevski was the first man ever to publish a non-euclidean geometry, though Bolyai's marvel of genius went perfect to the printer in the same year, 1829, the most extraordinary two dozen pages in the whole history of thought.

Bonola's book takes the developmental viewpoint, and the first 83 pages give a just and adequate account of the forerunners of non-euclidean geometry, with whom belong Schweikart, Gauss and Taurinus, though far greatest of whom was Saccheri.

The inadequacy of the book is in the 30 pages, out of 268, devoted to the real founders of non-euclidean geometry, John Bolyai and Lobachevski, whose very names Carslaw has

[1] SCIENCE, May 10, 1912, p. 736.

[1] Monist, 4, 483–493.

bungled. The name of the proud young Magyar, Bolyai János, Bonola correctly translates into Italian as Giovanni Bolyai, John Bolyai. Carslaw seems to think him an Austrian, and always calls him Johann (16 times or more). He might as well have called him Ivan. The young Hungarian had the racial hatred for Austrians. In garrison, 13 of them, cavalry officers, challenged him at once with the saber. He accepted, only stipulating that between each two duels he might play a piece on his violin. He was victor over all.

His father, Bolyai Farkas, could at need deal more tactfully with the common enemy. When an Austrian Schulrath was sent with hostile intent to inspect the protestant college at Maros-Vásárhely, a nest of Magyar rebels, old Bolyai Farkas received him with exceeding geniality, related with zest and fire the experiences of his student life in Germany, and took him to dinner. They ate, drank and talked like two German students. "The interests of the college required it, and they said 'Du' to one another." And that the Schulrath should see near him no rebel faces, Farkas bade his son sacrifice his beautiful beard. Bolyai won. The Austrian was kept away from the college.

Franz Schmidt told me in Budapest his father had seen Bolyai János in Temesvár in mere wantonness of the pride of life cut off with his beautiful Damascus blade an iron spike driven into his doorpost. And now Carslaw in English calls him Johann!

No better fares it with Lobachevski. Bonola gives his name in Italian as Nicola Ivanovic Lobacefski, in which the very same Russian letter B is twice transliterated v and then f. Carslaw makes the worse blunder of twice transliterating it v and then w. But another single Russian letter, equivalent to the Italian c, our ch as in church, Carslaw transliterates as four letters together, and so in translating the name, Carslaw gives it *seven* additional letters, and besides all that, a substitute letter w which wholly destroys the sound, since Carslaw's tschew can have in English only the sound made offensive by Fletcher.

The fault of the seriously unsatisfactory and misleading exposition of Lobachevski's transition work of 1826 is Bonola's. Bonola pretends to know all about the contents of this memoir, never printed and of which no manuscript has ever been found, while really oblivious to the never explained paradox of its very name: Exposition succincte des principes de la géométrie, avec une démonstration rigoureuse du théorème des parallèles. What a horribly unfortunate title for a man who three years later began to publish work which shows such "démonstration rigoureuse" eternally impossible! He never confesses what it was.

And again when he gradually became conscious of "the possibility of the existence of geometry in a wider sense than that in which Euclid first expounded it to us," that which young John Bolyai, with his magnificent nerve, in 1829 called "The Science Absolute of Space," Lobachevski in 1835 called "Imaginary Geometry." In 1855, going blind and dying, he gives it at last a more worthy name, Pangeometry, but dies without its having obtained the slightest public recognition and without having made a single disciple. Nothing could be more false than Carslaw's sentence, p. 86:

> Non-Euclidean Geometry, just as it was conceived by Schweikart in 1816, became in 1829–30 a recognized part of the general scientific inheritance.

In fact for more than a third of a century thereafter, it was as if it had never been born.

A voluminous work by the academician Buniakovski appeared in St. Petersburg in 1853 in which Lobachevski is not even mentioned, and in all his published works Gauss never even once mentioned the name of Lobachevski or of John Bolyai. Yet the two dozen pages of John Bolyai was something incalculably tremendous. Is then the silence of Gauss to be attributed to meanness or blindness? He said he "feared the outcry of the Bœotians," if he should speak. Max Simon says, 1901,

Never believe that Gauss ever doubted the actual truth of the parallel assumption for our space.

Yet just now, 1912, this space of ours is being proved non-euclidean by the principle of relativity. Says Vladimir Varićak in a wonderful lecture, "Ueber die nichteuklidische Interpretation der Relativtheorie,"[2]

I postulated that the phenomena happened in a Lobachevski space, and reached by very simple geometric deduction the formulas of the relativity theory. Assuming noneuclidean terminology, the formulas of the relativity theory become not only essentially simplified, but capable of a geometric interpretation wholly analogous to the interpretation of the classic theory in the euclidean geometry. And this analogy often goes so far, that the very wording of the theorems of the classic theory may be left unchanged.

To see that this will prove our space Bolyaian, we have only to remember Poincaré's dictum:

These two propositions, the earth turns round, and, it is more convenient to suppose that the earth turns round, have one and the same meaning.[3]

The first man to so bring forth the non-euclidean geometry that it was not stillborn, but lived and grew, was the Frenchman Hoüel, by his translations of Lobachevski in 1866 and John Bolyai in 1867. Thirty years later, in my translator's preface, I said:

No part of Lobachevski's largest work, "New Elements," has ever before been published in any language but the original Russian.

I gave an account of it in 1893 at the Mathematical Congress of the World's Columbian Exposition, and promised then the publication of my translation.[4] This promise was delayed for a personal visit to Kazan, the home of Lobachevski, and Maros-Vásárhely, the home of Bolyai. Only through his little book "Geometrical Researches,"[5] have Lobachevski's ideas been heretofore accessible to the world in general.

But it is preeminently in his "New Elements" that the great Russian allows free expression to his profound philosophic insight, which on the one hand shatters forever Kant's doctrine of our absolute *a priori* knowledge of all fundamental spatial properties, while on the other hand emphasizing the essential relativity of space.

The realities which with the aid of the euclidean space form we understand under motion and position, may, with the coming of more accurate experience, refuse to fit in that form. Our mathematical reason may decide that they would be fitted better by a non-euclidean space form. Space is presupposed in all human notions of motion or position. We may drop out such specifications from our space form as render it specifically euclidean. Euclidean space is a creation of that part of mind which has worked and works yet unconsciously.

It is not the shape of the straight lines which makes the angle-sum of a rectilineal triangle two right angles.

With straight lines of precisely such shape but in a non-euclidean space, this sum may be greater or less. In non-euclidean spaces, if one edge of a flat ruler is a straight line the other edge is a curve, if the ruler be everywhere equally broad. In any sense in which it can be properly said that we live in space, it is probable that we really live in such a space.

And now fifteen years later comes the relativity theory to prove all this, and to make non-euclidean geometry a powerful machine for advance in physics.

GEORGE BRUCE HALSTED
GREELEY, COLO.

Allen's Commercial Organic Analysis. Volume V. Tannins, Dyes and Coloring Matters, Inks. Edited by W. A. DAVIS and SAMUEL S. SADTLER. P. Blakiston's Son and Co. Philadelphia, 1911. Price $5.00.

This volume contains the following chapters: Tannins by W. P. Dreaper. Analysis of Leather by W. P. Dreaper. Dyes and Coloring Matters by W. P. Dreaper and E. Feilmann. Dyestuffs of Groups 6 to 12 by J. T. Hewitt. Coloring Matters of Natural Origin by W. M. Gardner. Analysis of Coloring Materials by W. P. Dreaper and E. Feilmann.

[2] *Jahresber. D. Math. Ver.*, 21, 103–127.

[3] "The Value of Science," Halsted's translation, p. 140.

[4] See "Mathematical Papers of Chicago Congress," pp. 92–95.

[5] Hoüel, 1866; Halsted, 1891.

Coloring Matters in Foods by Albert F. Seeker. Inks by Percy H. Walker. Index.

Volume VI. Organic Bases, Vegetable Alkaloids. Philadelphia, 1912. Price $5.00. This includes Amines and Ammonia Bases by W. A. Davis. Aniline and its Allies by S. S. Sadtler. Naphthylamines, Pyridine, Quinoline and Acridine Bases by W. H. Glover. Vegetable Alkaloids by Thomas A. Henry. Volatile Bases of Vegetable Origin by Frank O. Taylor. Nicotine and Tobacco by R. W. Tonkin. Aconite Alkaloids by Francis H. Carr. Cocaine by Samuel P. Sadtler. Opium Alkaloids by Frank O. Taylor. Strychnos Alkaloids by Charles E. Vanderkleed. Cinchona Alkaloids by Oliver Chick. Berberine and its Associates by Edward Horton. Caffeine, Tea and Coffee by J. J. Fox and P. J. Sageman. Cocoa and Chocolate by R. Whymper.

The extensive scope of the work and the pains taken to secure the assistance of experts in the various fields is well indicated by the list of chapters given.

W. A. Noyes

The Flight of Birds. By F. W. Headley, M.B.O.U., with sixteen plates and many text figures. Witherby and Co., 326 High Holborn, London. 1912. 12mo. Pp. xii + 163. Price 5 shillings.

In this little book Mr. Headley has endeavored to describe briefly and clearly the flight of birds, keeping in view the methods and difficulties of those who are striving to rival them. In ten chapters he deals with methods, modes and apparatus of flight, an eleventh chapter being devoted to some accessories, circulation, breathing, etc., that are connected with, or modified by flight.

The first chapter deals with gliding, the resistance of the air, the curve of the wings and the area of supporting surface, matters which lie at the base of all flight. We then pass to stability, including voluntary adjustment, the latter a point wherein the feathered biped has the great advantage over his featherless rival of many thousands of years' experience. What man has to think about, the bird does instinctively. It is this instinct that enables a bird to fly successfully at the first trial of his wings, although he can not handle them so dexterously as he will later on and they may not carry him so far nor so fast as they will subsequently. And just here may we say that a bird does not fly stupidly into a telegraph wire; he simply does not see it until too late to evade it. The *Titanic* did not run stupidly into an iceberg; by the time it could be seen she was upon it. Also horizontal wires are not within the province of the bird's instincts, and in the grouse districts of Scotland, bits of wood are hung on telegraph and telephone lines to catch the bird's eye.

In connection with the relation of the shape of the wings to stability, it may be said that Mr. Huffaker, one of Professor Langley's assistants, reached the conclusion that the curved secondaries and more or less flattened primaries of the bird's wing were the great factors in stability and that the flattened wing tips also served as horizontal rudders, points wherein man has advantageously patterned after the bird.

Then come starting and steering, and the machinery of flight, muscles and bones. A little more space, perhaps, might have been devoted to the framework and to some of the rather perplexing problems it suggests—why is it that while sailing birds, the albatross and frigate bird, for example, have very small muscles their shoulder girdles are most rigidly constructed, the coracoid, clavicle and breastbone of the latter being immovably soldered together. In the great pterodactyl, *Pteranodon,* most marvelous of all flying creatures, we have in the massive collar bone special provision for bracing the wings. Perhaps in all these cases this strength is necessary, because the muscles themselves can not be relied upon to stand the strain. But in the almost flightless hoatzin we find the apparent anomaly of a rigid shoulder girdle. We think that, as is usually done, too much value is put upon the clavicle as a brace to the coracoids. Among the birds of prey it is of importance, but in the ducks and pheasants, birds of powerful flight, it is a negligible quantity; so it is in

humming-birds and swifts, and some of the best flyers among parrots have an imperfect clavicle.

Chapter three deals with motive power, leverage, propulsion, wing stroke and the manner in which the wings attack the air, a manner well described on page 45.

Here, too, a query. Mr. Headley thinks that the kestrel can not hover unless the wind is blowing against him. We believe that the kingfisher *can* do this, and the humming-bird and hawk moth will hover above a flower and circle around it with no apparent difficulty. Mr. Headley points out that quality of muscle is quite as important as quantity, and notes that while ordinarily the elevator muscles are inferior to the depressor, in the guillemot, a swimming bird, they are on a parity. Undoubtedly his explanation is correct; the bird that uses its wings to fly beneath the water needs powerful muscles to raise them. This is in line with the deeply keeled sternum and abundant muscles of the penguin and great auk, birds incapable of aerial flight, that wing their way swiftly beneath the water.

Further chapters deal with the relation between the form of wings and mode of flight, speed and endurance and the influence of the wind. Here we find repeated the theory that soaring (circling upward) is made possible by upward currents of wind, a theory that we think few will find satisfactory. A bird may circle about in such a current, but it would not have strength enough to raise him and we feel that the most that can be said is that in some way, as yet beyond our power of imitation, birds, so to speak, screw themselves through the air to vast heights, over the level pampas as well as over the gusty mountain tops.

But one can not indulge in much discussion in little more than 150 pages and the average reader will prefer to have the facts rather than theories: and Mr. Headley has done well to give us so many facts and so much well-told information in so small a compass.

A feature of the book are the illustrations of birds, mainly pigeons, and for the most part from Mr. Headley's photographs, in various phases of flight. These give an idea of the varied poses of the wings and tail, and their relation to the balance of the bird, or direction of its flight, that can not be gained from words.

F. A. L.

SPECIAL ARTICLES

THE EVENING PRIMROSES OF DIXIE LANDING, ALABAMA

BARTRAM'S locality for *Œnothera grandiflora* at Dixie Landing on the Alabama River some distance above Fort Mimms (1778) was rediscovered by Professor S. M. Tracy in 1904 and visited a second time by him in 1907. Seeds procured by Tracy have been widely distributed and have given rise to races of *Œnothera grandiflora* which are being studied by several investigators.

Œnothera grandiflora is one of the nearest allies of *Œ. Lamarckiana* and seems to agree with that species in at least some points pertaining to mutability and behavior on hybridizing. Its study may at some time lead to an explanation of those phenomena which until a short time ago seemed peculiar to *Œ. Lamarckiana*. Consequently it seemed to us to be of primary importance to study *Œ. grandiflora* in its original habitat, and we visited Dixie Landing under the kind guidance of Professor Tracy, on September 26 and 27.

It had been known from cultures grown by Professor B. M. Davis from Professor Tracy's wild seed that *Œ. grandiflora* did not occur at Dixie Landing as a single pure strain. It was no surprise, therefore, to find growing in the old cotton fields several forms of *Œ. grandiflora*, together with several forms of its companion species *Œ. Tracyi*, which has recently been described by one of us. The plants were partly in flower and partly in the rosette condition. Neither *Œ. grandiflora* nor *Œ. Tracyi* has heretofore been known as other than annual, and the abundance of rosettes which would obviously not flower this season was therefore a point of great interest. Seeds were obtained from all strains which had ripe capsules, and in addition a large collection of

rosettes was sent to Washington to be grown there.

The evening primroses are found all along the river bluffs, often at the very edge of the perpendicular bank, which is some twenty feet higher than the river. In the old cotton fields they evidently find a favorable habitat, as may be concluded from their abundance in even very recently cultivated fields. The two species, *Œnothera grandiflora* and *Œ. Tracyi* were found growing together in all the fields which we studied, including those from which Professor Tracy's seed had been obtained in former years. Really pure stands of *Œ. grandiflora* we failed to find either in the old fields or in the woods along the river. Intermingled with the most frequent types of *Œ. grandiflora* and *Œ. Tracyi* were numerous less abundant types. This was particularly true in the old fields. It is hardly probable that all of the types which occur at Dixie Landing were observed by us. The following types, designated by letters from *a* to *l*, were noted, and of some of them seeds were obtained. Of other types, which were just coming into flower, seeds could not be obtained, but it is hoped that these will be found in the collection of rosettes which was sent to Washington.

1. Types like *Œ. grandiflora, i. e.,* types having large flowers with the style longer than the stamens: (*a*) with green, glabrous calyx segments and short capsules; (*b*) with green, viscid-puberulent calyx segments and short capsules; (*c*) with red-spotted, glabrous calyx segments and short fruit; (*d*) with red, glabrous calyx segments and long capsules; (*e*) with red-spotted, viscid puberulent calyx segments and short capsules; (*f*) with red-spotted glabrous calyx segments and petals orange-colored on wilting (all the other types were light yellow on wilting); (*g*) with red-spotted, glabrous calyx segments and pinnatifid leaves (all the other types had the leaves merely dentate or subdentate).

2. Types like *Œ. Tracyi, i. e.,* with flowers medium sized and stamens reaching the stigmas: (*h*) with green calyx segments and green, pilose capsules; (*i*) with green calyx segments and green, glabrous capsules; (*j*) with red-spotted calyx segments and green, pilose capsules; (*k*) with red-spotted calyx segments and pilose, longitudinally red-striped capsules; (*l*) with red calyx segments and green capsules, a beautiful form the coloration of which suggests that it may be a variant of *Œ. Tracyi* parallel to certain of the Amsterdam mutants of *Œ. Lamarckiana.*

The classification of the types of *Œ. grandiflora* does not take into consideration the pubescence of the stem, which varies widely, the shape of the leaves, which is equally variable, or the mode of branching, which can not be accurately judged in specimens growing under the diverse conditions afforded by the habitat at Dixie Landing. It should be noted that all of the *Œnothera grandiflora* types had glabrous, green capsules, that none of them were at all ambiguous with respect to the size and position of the floral parts, and that none of them could be considered at all similar to the *Œ. Lamarckiana* of the Amsterdam cultures. A very few specimens were found of which the broad leaves were somewhat crinkled, but so slightly so as to suggest that the variation was merely individual or accidental.

The classification of the types of *Œ. Tracyi* takes no account of the width of the leaves, or of the degree and kind of pubescence. Of course a more complete analysis of the composition of the *Œnothera* population at Dixie Landing will be made when the rosettes have flowered in Washington and a second generation has been grown from self-pollinated seed of all the forms found in the collection. At the present time it is sufficient to point out that no *Œnothera* from Dixie Landing, however constant it may seem to be when grown generation after generation from self-pollinated seed, can be cleared of the suspicion that it may be of hybrid origin. In other words, the same suspicion that attaches to so many of the strains of *Œnothera Lamarckiana* in Europe attaches to any strain of *Œnothera grandiflora* which is now being used by experimenters.

It is therefore of some importance to compare the conditions under which *Œ. grandi-*

flora grows at Dixie Landing with the conditions under which *Œ. Lamarckiana* occurs at its European stations. The race of *Œ. Lamarckiana* which occurs at Hilversum is unmixed, since no other species of *Œnothera* grows at that locality. Of its mutants only *Œ. læviflora* and *Œ. brevistylis* have been observed to flower regularly in the field: the other forms either do not flower at all or only so rarely as to have hardly any influence on the purity of the strain. In the sand dunes of Holland, on the contrary, *Œ. Lamarckiana* is mixed, as a rule, with European *Œ. biennis* and is observed to produce the three different hybrids which are obtained when these two species are artificially hybridized. The same statement holds good for many localities where the two species grow in France and England. Every individual from such a station, however closely its external characters may seem to coincide with those of one of the parent species, must always lie open to the suspicion of having had a hybrid ancestry.

In connection with the fact that the Dixie Landing types are so sharply divisible into two groups, it is permissible to suggest that they may correspond in a general way with hybrids between *Œ. Lamarckiana* and *Œ. biennis* "Chicago" which have already been studied. From the cross *Œ. Lamarckiana* × *Œ. biennis* "Chicago" and its reciprocal, two pairs of twin hybrids were obtained at Amsterdam in the first generation, viz., *Œ. læta* and *Œ. velutina,* and *Œ. densa* and *Œ. laxa.* The first pair of twins, from the cross *Œ. Lamarckiana* × *Œ. biennis* "Chicago," has already been described, the other pair, from the reciprocal cross, will soon be published in another paper. Possibly one group of the Dixie Landing types is related to *Œ. grandiflora* in the same way that *Œ. densa* and *Œ. læta* are related to *Œ. Lamarckiana,* and the other group to *Œ. Tracyi* as *Œ. laxa* and *Œ. velutina* are related to *Œ. biennis* "Chicago." Of course the situation at Dixie Landing is probably complicated by the recrossing of the hybrids with themselves and with their parents. However that may prove to be, the Dixie Landing types are now available for study and it is hoped that future work may show in what manner they are related. At the present time no conclusion regarding them is justified other than that they constitute so mixed a population that it is quite impossible to distinguish original parent types, if any such exist there, from the derivative types associated with them. In case the two most common types represent the original strains, the presence in other types of characters which are not common to either hypothetical parent suggests that *Œ. grandiflora* and *Œ. Tracyi* may prove to be additions to the list of species, including *Œ. Lamarckiana, Œ. cruciata* "Adirondack," European *Œ. biennis,* and *Œ. biennis* "Chicago," which are known to be in a mutable condition.

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THE GREAT CRESTED GREBE AND THE IDEA OF SECONDARY SEXUAL CHARACTERS

CERTAIN facts in the structure and habits of this bird (*Podiceps cristatus* L.) have such a general bearing upon the whole conception of secondary sexual characters that it seems desirable to publish them here. The facts are these: the great crested grebe possesses an erectile ruff at the sides of the neck and a pair of erectile tufts on the head. The male is slightly larger in total size, and his ruff and tufts are also slightly larger, relatively as well as absolutely; otherwise the sexes are identical. The ruff and tufts are used extensively in courtship; at other times they are only occasionally erected, and then never to their full extent. The courtship-actions, including all the movements of ruff and tufts, are identical in the two sexes. The ruff and tufts and the actions in which they are concerned would be called secondary sexual characters, were they not common to both sexes, for secondary sexual characters are always defined with regard to this very point, their difference in the two sexes. I take a random

definition, chosen for its brevity. Dewar and Finn[1] say that they are "those characters which differ with the sex, but are not directly connected with the act of reproduction." Darwin[2] defines them very similarly, but then adds:[3]

> There are, however, many animals in which the sexes resemble each other, both being furnished with the same ornaments, which analogy would lead us to attribute to the agency of sexual selection. . . . It is probable that the ornaments common to both sexes were acquired by one sex, generally the male, and then transmitted to the offspring of both sexes.[4]

As far as I can understand, however, he is talking merely of structures, not of those combinations of a structure with the instinct for displaying that structure which constitute the real secondary sexual *characters*.

The grebe is, so far as I know, unique in this—that structures which are only used in courtship (*i. e.*, which must *in origin* be due to sexual and not to natural selection) are now not only the common property of both sexes, *but are actually used in display, and used in exactly the same way by both sexes.*

The question of nomenclature remains; what are we to call characters like these, that have arisen through sexual selection, but exist equally in both sexes? The term "secondary sexual," as we have seen, will not do. A word does exist, however, which is perfectly applicable, and that is the word *epigamic*.[5] It would indeed be more satisfactory if we were always to use the term *epigamic* of all characters that owed their origin to sexual selection, whether they are found in one or both sexes, and keep the term *secondary sexual* in the wider sense that it often has now, to include *all characters peculiar to one sex except the primary sexual characters* (of gametes and gonads) *and the accessory sexual characters* (of genital ducts, copulatory apparatus, etc.). This would cover such epigamic characters (the great majority) that are confined to one sex, as well as many other characters, such as the mammæ of female mammals or the wingless condition of various female moths, which are not epigamic, nor accessory in the strict sense of directly helping the union of the gametes, but have been evolved through natural selection to perform some special function of their own.

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Balliol College, Oxford,
July, 1912

[1] "The Making of Species," 1909, p. 298.

[2] "Descent of Man," 1871, p. 253.

[3] *Ibid.*, p. 277.

[4] There is no necessity to multiply quotations; I will merely refer the reader to some apposite passages, *e. g.*, Poulton, "Essays on Evolution," 1908, pp. 379, 380; Archdall Reid, "Laws of Heredity," 1910, p. 145; Weismann, in "Darwin and Modern Science," 1909, pp. 43, 48; in "The Evolution Theory," 1904, Vol. I., pp. 232, 233.

[5] Poulton, *loc. cit.*

VOLCANIC ACTION IN THE BLACK HILLS OF SOUTH DAKOTA[1]

In recent work on geology of the northern Black Hills I have found a sheet of obsidian and associated agglomerates which doubtless are the products of surface extrusion. The locality is 1¼ miles northwest of Roubaix or 6 miles south by east of Deadwood in the midst of a large area of pre-Cambrian schists. The many large masses of igneous rocks in this region are well known from descriptions by Newton, Crosby, Jaggar and others, but so far as recorded they are of intrusive nature and of early Tertiary age. The White River deposits (Oligocene) in and about the Black Hills contain large amounts of fragments of these igneous rocks, the products of erosion, and also much volcanic ash of contemporaneous origin. The source of this ejected material has always been a problem, and while the effusive rocks near Roubaix can not be precisely correlated with White River deposits they appear to indicate that there was volcanic action in this region in mid-Tertiary time.

The obsidian is a sheet about 15 feet thick and of small extent. Its smooth lower surface lies on a one-foot layer of impure volcanic ash which is underlain by a thick mass of agglomerate or flow breccia of apparent rhyolite

[1] Published by permission of the Director of the U. S. Geological Survey.

fragments. This breccia is in masses surrounded by a deposit of finer-grained agglomerate which is nearly a square mile in extent. Other smaller masses of similar agglomerates were found five miles southeast of Roubaix. These occurrences are remnants of larger masses, for they have been subject to extensive erosion. The original vents are not preserved but their stocks are now represented by some of the dikes which occur at many places in the schists or overlying Paleozoic rocks.

These facts suggest that the Black Hills may have been the source of part if not all of the large amount of the volcanic ash which occurs intermixed and interbedded in the deposits of Oligocene age as well as in later formations in various parts of South Dakota and Nebraska.

N. H. DARTON

U. S. GEOLOGICAL SURVEY

INTERNATIONAL CONGRESS OF PREHISTORIC ANTHROPOLOGY AND ARCHEOLOGY

THE fourteenth International Congress of Prehistoric Anthropology and Archeology was held in the aula of the university, Geneva, September 9–14, 1912. On the evening of the 8th, Professor Eugene Pittard, president of the congress, and Professor Edouard Naville, honorary president, received the members informally at the Atheneum. The attendance was good throughout the week, 149 delegates being present from 112 institutions representing at least 20 nations, 12 of which sent government delegates. A. Hrdlička, George Grant MacCurdy and Charles Peabody represented the United States government. The total enrollment was nearly 600.

It had been over six years since the last congress (Monaco) was held. In view of the immense progress made in the domain of the prehistoric during this time, the program was exceptionally long and interesting. As no provision had been made for a division of the program into sections each treating a related group of subjects, it was necessary not only to limit each speaker to ten minutes, but also to abridge the discussion far beyond a desirable limit. Fortunately, however, many of the papers were supplemented by generous exhibits of original specimens, casts, drawings, plans, photographs, etc., for which the university furnished suitable cases and ample wall space conveniently located. The large collection of original specimens from Spain including remains of *Elephas antiquus* associated with a Chellean and perhaps pre-Chellean industry, and the Celti-iberian sepultures, exhibited by the Marquis of Cerralbo deserve special mention. Other exhibitors, to all of whom the thanks of the members present are due will be indicated in the program that is to follow.

The following amendments to the constitution recommended at the Congress of Monaco, were adopted at the first seance of the Geneva Congress and went immediately into effect:

> The official language of the congress is French; it is used for the publication of the proceedings and the correspondence of the commission of organization and of the committee. However, the members of the congress may, in their letters, communications or readings, make use of German, English or Italian. Communications in these three languages shall be accompanied by a résumé in French, and the discussions before the congress shall continue to be made in French.
>
> The maximum number of communications which any author may enter on the program is limited to four.

At the same seance an anthropometric commission consisting of the following members was appointed to continue the work of unification of anthropometric measurements begun at the Congress of Monaco[1] and to report at the close of the session:

MM. Chantre (France), Czekanowski (Russia), Duckworth (Great Britain), Frassetto (Italy), Giuffrida-Ruggeri (Italy), Godin (France), Hillebrand (Hungary), Hoyos Sainz (Spain), Hrdlička (United States), Loth (Russian Poland), von Luschan (Germany), MacCurdy (United States), Manouv-

[1] Compte Rendu, Congr. intern. d'anthr. et d'archéol. préhs., 13e session, Monaco, 1906, tome II., pp. 377–394.

rier (France), Marett (Great Britain), Mayet (France), Mochi (Italy), Musgrove (Great Britain), Pittard (Switzerland), Rivet (France), Schlaginhaufen (Switzerland), Sergi (Italy), Sollas (Great Britain), Volkov (Russia), Weisgerber (France).

This commission held four meetings, on the 11th from 8 o'clock till noon under the presidency of Manouvrier; on the 13th from 8 o'clock till 11 and from 3 till 4 under the presidency of Sergi; on the 14th from 9 till 10 under the presidency of Duckworth.

The reporters appointed were Duckworth, Rivet and Schlaginhaufen.

The entire report was adopted unanimously by the commission in the meeting of the 14th, and by the congress on the same day in its closing session.

International Agreement for the Unification of Anthropometric Measures on the Living

General Principles

(*a*) For measurements on living subjects, the upright position is adopted.

(*b*) The projection method is adopted, except in cases where special mention is made of a different method.

(*c*) For paired measurements, it is recommended to operate on the left side and to take bilateral measurements for the height of the acromion and the great trochanter above the surface on which the subject stands.

(*d*) Observers are urged always to indicate precisely their method and instrumentation.

(*e*) It is very particularly recommended to persons desirous of using anthropometry not to be content with a theoretical study of the measuring processes, but to learn them practically in the different laboratories where they are taught.

Measures in Detail[2]

1. *Height.*—Subject standing on a horizontal firm surface (not leaning against a vertical wall or support), the arms pendent, the palm of the hand turned inward, the fingers vertical, the heels touching, the eyes directed horizontally. In this position measure the height of the vertex above the horizontal surface on which the subject stands.

[2] Translated from Dr. Rivet's copy. Measures marked by an asterisk are those for which the subject should be in the same position as for the height (measure No. 1).

*2. *Auditory Opening.*—Starting point: the deepest portion of the notch between the tragus and the helix (point already adopted at the Monaco Congress, op. cit., p. 391).

*3. *Chin.*—Starting point: median point on the inferior border of the mandible.

*4. *Presternal Notch.*—At its lowest point.

*5. *Nipple.*—Start from its center. Exclude women with pendent breasts.

*6. *Umbilicus.*—Center of the umbilical cicatrice.

*7. *Pubis.*—Median point on the superior border of the pubis. In cases where it is difficult to locate this point, be guided by the lower ventral fold.

*8. *Spinous Process of the Fifth Lumbar Vertebra.*—To find this point easily, cause the trunk of the subject to be flexed, a position in which the spinous process in question is indicated by a prominence.

9. *Height Sitting.*—Cause the subject to be seated on a stool, horizontal and firm, 30 to 40 cm. in height (this height varying with the height of the subject), the legs flexed. Place the back in contact with a vertical plane or with the anthropometer at the level of the sacral region and between the two shoulder blades. The head should be in the same position as for the height standing. Measure the height of the vertex above the horizontal plane of the stool.

10. *Height of the Pelvis.*—The subject being in the position for the height sitting, measure the height of the summit of the iliac crest above the plane of the stool.

*11. *Acromion.*—Upper external border of the acromion.

*12. *Great Trochanter.*—Upper border of the great trochanter.

*13. *Anterior Superior Iliac Spine.*—Summit of this spine. In cases where it is difficult to find this point, follow Poupart's ligament to its point of insertion, which is precisely the spine in question.

*14. *Elbow.*—Radio-humeral line.

*15. *Wrist.*—Inferior point of the styloid process of the radius.

*16. *Extremity of the Middle Finger.*

*17. *Knee.*—Point on the upper margin of the internal tuberosity of the head of the tibia.

*18. *Ankle.*—Inferior point of the internal malleolus.

*19. *Stretch.*—Place the subject against a wall, the arms extended horizontally, the hands completely open, the palm forward, and measure the

distance from the extremity of one middle finger to that of the other. If no wall is to be had, place the rigid anthropometer horizontally behind the subject, whose position should be the same as above described, and take the same measure. Whichever method is employed, demand of the subject the maximum extension.

*20. *Biacromial Diameter.*—Maximum distance between the two acromions.

*21. *Bihumeral Diameter.*—Maximum distance between the two deltoid prominences (measure of secondary importance).

*22. *Bimamelon.*—Distance between the centers of the two nipples (same observation as for measure No. 5) (secondary measure).

*23. *Biiliac Diameter.*—Maximum distance between the external margins of the iliac crests.

*24. *Bispinal Diameter.*—Distance between the two anterior superior iliac spines (cf. measure No. 13).

*25. *Bitrochanteric Diameter.*—Maximum distance between the external faces of the great trochanters. It is necessary to press firmly against the tissue.

*26. *External Antero-posterior Diameter of the Pelvis.*—Starting points: in front, upper border of the pubis and in a median line; behind, summit of the spinous process of the fifth lumbar vertebra.

*27. *Transverse Diameter of the Thorax No. 1.*—Measured in a horizontal plane at the level of the xiphoid appendix. Take the average of the measures noted during inhalation and exhalation, or take the measure in an intermediate state.[2]

*28. *Transverse Diameter of the Thorax No. 2.*—In a horizontal plane at the level of the upper border of the fourth chondro-sternal articulation (secondary measure).

*29. *Antero-posterior Diameter of the Thorax No. 1.*—In the same plane as measure No. 27.

*30. *Antero-posterior Diameter of the Thorax No. 2.*—In the same plane as measure No. 28 (secondary measure).

*31. *Height of the Sternum.*—Measured with sliding compass from the lowest point of the presternal notch to the base of the xiphoid appendix.

32. *Bicondylar Diameter of the Humerus* (secondary measure).

33. *Bistyloid Diameter of the Forearm* (secondary measure).

[2] For measures Nos. 27–29 it is necessary to employ calipers with large blunt extremities, as the points of ordinary calipers would slip into the intercostal spaces, thus falsifying the results.

34. *Bicondylar Diameter of the Femur* (secondary measure).

35. *Bimalleolar Diameter* (secondary measure).

*36. *Thoracic Circumference.*—In a horizontal plane at the level of the base of the xiphoid appendix (secondary measure).

37. *Circumference of the Neck.*—The smallest circumference.

38. *Circumference of the Arm.*—The maximum circumference below the deltoid, the arm being in a state of repose.

39. *Circumference of the Arm in Contracted State.*—Maximum circumference at the same level as measure No. 38 (secondary measure).

40. *Maximum Circumference of the Forearm.*—At the level of the epitrochlear and epicondylar muscles.

41. *Minimum Circumference of the Forearm.*—Above the styloid processes of the radius and ulna.

42. *Maximum Circumference of the Thigh.*—At the level of the gluteal fold.

43. *Minimum Circumference of the Thigh.*—Just above the knee.

44. *Circumference of the Calf.*—The maximum.

45. *Minimum Circumference of the Ankle.*

46. *Minimum Circumference of the Waist.*

47. *Contour of the Hand.*—The right hand is applied on a leaf of paper, the fingers moderately separated, the axis of the middle finger in line with the axis of the forearm. Mark the two extremities of the bistyloid line, from these points trace the contour of the palm and fingers with a pencil cleft longitudinally and held perpendicular to the paper. Mark by points the termination of each interdigital space and the metacarpo-phalangial articulation at each side.

48. *Contour of the Foot.*—The right foot is placed on a leaf of paper, the leg being perpendicular to the paper. Mark by a stroke the extremities of the malleoli and the metatarso-phalangial articulation at each side; then trace the contour of the foot and toes in the same way as for measure No. 47, indicating the termination of each interdigital space. It is useless to trace the internal border between the malleolar and the metatarso-phalangial points, as it would always be inexact.

49. *Height of the Arch.*—The foot in the same position as for measure No. 48, measure by means of a vertical sliding compass the vertical distance from the plane of support to the upper border of the scaphoid (secondary measure).

The Anthropometric Commission as well as

the congress unanimously adopted the following technique and resolutions:

RECONSTRUCTION OF THE HEIGHT BY THE AID OF THE LONG BONES

To reconstruct the height by the aid of the long bones, measure the maximum length of these bones, with the exception of the femur, which is to be measured in position, and of the tibia, which is likewise to be measured in position, without the spine.

Resolutions

1. *Resolved,* that for the graphic representation of skulls, anthropologists employ the horizontal plane either of Broca or of the Frankfort agreement.

2. *Resolved,* that anthropologists publish integrally all their measures.

It was voted to recommend to the next congress, which will no doubt be held at Madrid in 1915, an amendment to the constitution admitting Spanish on the same footing as English, German and Italian (a similar recommendation to admit all the Slavic languages was rejected); also that hereafter the program be divided into sections: (1) the stone age, (2) the age of metals and (3) anthropology properly so called (somatology), with the understanding, however, that communications comprehensive in character should still be treated in general session.

The following resolutions were adopted:

1. Asking Slavic societies and authors to give résumés of their publications in French, German or Latin.

2. That in view of the danger to originals from fire and theft, museums possessing important prehistoric or protohistoric objects made of precious metals be asked to have the same reproduced in metal or plaster.

3. That this congress enter into amical relations with an international congress[4] now in process of formation and destined to cultivate particularly the field of ethnography and physical anthropology.

The council in which this last resolution took shape were of the opinion that the name eventually to be chosen for the new congress should not be such as would lead to confusing it with that of the existing congress, and that the two should not meet in the same year. The fifteenth session of the International Congress of Prehistoric Anthropology and Archeology will be held in 1915, at Madrid in case of an official invitation. The new international congress, as yet unnamed, will probably take final shape at the Washington meeting of the International Congress of Americanists, and the first session perhaps called for 1916.

The one fact that stood out most impressively at Geneva was the recent development of the prehistoric in Spain, on the one hand by the Marquis of Cerralbo and on the other by the Institut de Paléontologie Humaine in Paris, an international institution founded by the Prince of Monaco. Within the last five years the Marquis of Cerralbo has in his private capacity excavated fifty-two prehistoric stations and is now carrying on work at ten. Through his efforts the government of Spain founded last June a Commission de Exploraciones Espeleologicas, a branch of the Instituto Nacional de Ciencias Naturales. This foundation was inspired in a large measure by the success of the Institut founded by the Prince of Monaco. It is fortunate that prehistoric archeology should have the powerful support of two such influential men, both of whom received a special vote of thanks of the congress. Another name that should not be overlooked in this connection is that of M. Louis Siret, a Belgian with large business interests in Spain, who for many years has made good use of his exceptional archeological opportunities. If the present rate of progress continues along these lines during the next three years, the Madrid congress will be a pilgrimage that no prehistorian can afford to miss.

The social functions of the week were especially well regulated and highly enjoyed by all present. Each member was given a "carnet" which contained not only the dates and places of the events, but also free coupon tickets to and from each function. On Monday from 5 to 8:30 P.M. Professor Edouard Naville (honorary president) and Mme. Naville received at their beautiful country place, Malagny, near Geneva. The whole of Tues-

[4] See SCIENCE, N. S., XXXV., 980, 1912.

day afternoon was devoted to an excursion to Salève, where President Pittard gave an interesting talk on "The Prehistoric of the Environs of Geneva." Thursday afternoon the city council of Geneva received at the Ariana Museum; and in the evening Professor Oscar Montelius, of Stockholm, gave an illustrated lecture on "The Relations between Italy and Central Europe during the Bronze Age." A tour of the Lake of Geneva (or Lake Léman as the inhabitants of the Canton of Vaud prefer to call it) occupied the whole of Thursday with luncheon in the historic Castle of Chillon offered by the state council of the Canton de Vaud, and dinner on board the boat offered by the local committee of the congress. The city waterfront was brilliantly illuminated for the return at 8 P.M. The city of Geneva was hostess Friday afternoon from 4 to 6 at the new Museum of Art and History (containing also important prehistoric collections). The same evening Professor Émile Cartailhac lectured before a large audience in Victoria Hall on "Man of the Caverns." The official banquet in the foyer of the theater Saturday evening offered by the state council of the Republic of Geneva and followed by a representation of a "Fête Montagnarde" closed the festivities of the week. It was made the occasion of the official announcement of the founding of an Institute of Anthropology at Geneva, that President Eugene Pittard was to be the director and that in addition to the professorship, ample funds had been raised by private subscription to meet the annual needs of such an institute. In preparation for, and especially during the week of the congress, Professor Pittard abundantly demonstrated his fitness for the new post to which he has been called; and Geneva did well to honor him in the presence of his colleagues assembled from all parts of the world.

About forty members accepted the invitation to take part in a five days' excursion (September 16–20) to important lake dwellings and museums—Bevaix (Treytel), Neuchâtel, St. Blaise, La Tène, Bienne, Bâle, Zürich, Lucerne, Lausanne.

The following is a complete list of the papers presented at the congress:

J. Bayer: "The Glacial Periods (theories of Penck)."

Abbé H. Breuil: "The Subdivisions of the Upper Paleolithic and their Significance."

J. Hillebrand: "The Paleolithic Cavern of Pesko, Hungary." (Exhibit of original specimens.)

L. Capitan: "The Evolution of the Stone Industry during the Paleolithic."

Marquis of Cerralbo: "Torralba, the Most Ancient Station of Europe in which Archeological Remains have been found." (Exhibit of original specimens.)

V. Commont: (1) "Chronology and Stratigraphy of Neolithic and Paleolithic Industries in the Holocene and Pleistocene Deposits of Northern France, especially in the Valley of the Somme." (2) "A Mousterian Industry Associated with a Warm Fauna in the Valley of the Somme." (Exhibit of original specimens.)

A. Mochi: "The Succession of Paleolithic Industries and Changes in the Pleistocene Fauna in Italy." (Exhibit of original specimens.)

M. Anton: "New Quaternary Crania from Spain." (Exhibit.)

L. Capitan and D. Peyrony: "The Recent Discovery of Two Mousterian Skeletons at La Ferrassie (Dordogne)."

L. de Hoyos Sainz: "Crania of the Cro-Magnon Type from Old Castille." (Exhibit of photographs and maps.)

R. R. Marett: "Prehistoric Man in Jersey."

M. Boule: (1) "*Homo neandertalensis* and the Place it should occupy among the Hominidæ." (Exhibit of casts.) (2) "The Institute of Human Paleontology in Paris."

Giuffrida-Ruggeri: "A Scheme of Classification for Living Hominidæ."

Count Bégouen: "A New Cavern with Parietal Engravings in the Department of Ariège: the Cavern of the Tuc d'Audoubert." (Exhibit.)

Abbé H. Breuil and L. Capitan: "Engravings on Stalagmite from the Cavern of Teyjat, Dordogne." (Exhibit of original drawings.)

I. Dharvent: "The First Step in the Prehistoric Art of Europe."

M. Hoernes: "The Prehistoric Art of Europe by Epochs and Regions."

B. Reber: (1) "The Age and Significance of the Prehistoric Engravings." (Exhibit.) (2)

"Certain Series of New Prehistoric Engravings." (3) "Prehistoric Fortification in the Neighborhood of Geneva."

S. Reinach: "Some Specimens of Cavern Art."

L. Coutil: "Tardenoisian, Capsian, Getalian, Geneyenian (geometric flints)." (Exhibit.)

L. Didon: "An Aurignacian Station near Sergeac."

G. Jousset de Bellesme: "Comparative Technique in the Amygdaloid Type of Industry."

The Abbés H. Obermaier and H. Breuil: "Excavations at the Cavern of Castillo (Spain)."

G. Lalanne: (1) "The Venus of Laussel." (Exhibit of casts.) (2) "Azilian Stations on the Shore of Bas Medoc."

E. Pittard: (1) "The Prehistoric in the Valley of Rebières." (2) "Aurignacian Station: Les Rebières II." (Exhibit of original specimens.)

E. Pittard and R. Montandon: "An Aurignacian Microlithic Industry." (Exhibit of original specimens.)

R. A. Smith: "An Aurignacian Facies in England." (Exhibit of original specimens.)

Th. Volkow: "Recent Discoveries in a Paleolithic Station at Mélène, Ukraine." (Exhibit of original specimens.)

M. Baudouin: "The Orientation of Dolmens."

Baron A. Blanc: "Excavations in Savoy: Preliminary Results, Azilian, Neolithic, Eneolithic and Protohistoric."

Marquis of Cerralbo: (1) "Iberian Necropoles." (Exhibit.) (2) "Neolithic Monuments of Central Spain."

H. Corot: (1) "Prehistoric and Protohistoric Times in Alesia." (2) "The Excavation of a Tumulus at Minot, with Incineration 'in domo.'"

Abbé F. Hermet: (1) "Statue Menhirs of Aveyron and of Italy." (2) "Bronze Spheroids." (3) "The Sepulcral Cavern of Nant."

R. A. Stewart-Macalister: (1) "Some Excavations recently made in Ireland." (2) "A Neolithic Cavern at Ghezer (Palestine)."

D. MacRitchie: (1) "Cyclopean Constructions in Scotland." (2) "The Kayak in Northeastern Europe." (3) "Pygmies among the Ancient Egyptians and the Hebrews."

J. de Saint-Venant: "Some Curious Iron 'Tranchets' of the La Tène Period."

Mme. Barnett: "Prehistoric Stone Amulets from Teotihuacan, Mexico."

A. Hrdlička: "The Remains in Siberia, Mongolia and other Parts of Eastern Asia of a Race that Peopled America."

Charles Peabody: "The Present State of the Question of Diluvial Man at Trenton, New Jersey."

N. H. Winchell: "Prehistoric Man in Kansas." Read by Dr. Peabody. (Exhibit of original specimens.)

L. Siret: "Comparative Study of the Symbols Represented on Protohistoric Monuments or Objects."

M. Baudouin: (1) "Comparative Study of Pediform Sculptures and Engravings." (2) "Comparative Study of Engravings Representing the Horse's Foot."

J. Déchelette: "Origin and Use of Iron in Europe."

M. Exsteens: "Industry of the Extinct Tasmanians."

H. Müller: (1) "Stations with Azilian Facies from the Neighborhood of Grenoble." (2) "The Necessity of an International Commission on Archeological Nomenclature."

Mme. Crova: "Neolithic Implements from the Coast of Mauritania, Africa." (Exhibit of original specimens.)

H. S. Wellcome: "Prehistoric Discoveries in the Soudan." (Exhibit.)

F. Huybrigts: "The Earliest Manifestations of Religious Ideas by Neolithic and Druidic Populations according to the Discoveries made at Tongres, Belgium." (Exhibit.)

L. Schaudel: "Pitted Stones, their Origin, Significance and Destination."

G. B. M. Flamand: (1) "Prehistoric Sahara." (2) "The Worship of the Sun in Prehistoric Times."

F. Sarasin: "Colored Pebbles from the Cavern of Birseck, near Bâle." (Exhibit of original specimens.)

G. Nicole: "Prehistoric Vases from Thessaly."

H. Hubert: "The Androphagous Carnivor of the Gundestrup Vase." Read by S. Reinach.

G. Reubel: "An International Organization for the Anthropometry of Children."

P. Godin: "The Relation between the Evolution of Growth and Puberty."

S. Reinach: "An Iberian Ornament." (Exhibit.)

H. M. Ami: "The Status of Archeological Work in Canada."

L. Bidault de Grésigny: "Prehistoric Researches in the Saône Valley."

C. Florence: "How to Recognize the Age of Ferruginous Scoria."

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